ECOLOGICAL STUDIES OF THE EASTERN AND LEAST CHIPMUNKS

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ABSTRACT

Eastern and least chipmunks in the Itasca Park region of Minnesota are found to be ecologically distinct from each other. They differ from each other in: 1) habitat, 2) daily and seasonal activity patterns, 3) time of appearance aboveground of young, 4) food habits, 5) gross water requirements, and 6) ability to enter hibernation. They probably differ from each other in the time of onset of reproductive activity and perhaps in the ability to accumulate hibernation fat. The two species do not differ from each other in relative water requirements or in active or sleeping body temperatures. The sleeping eastern chipmunks, however, show much more variability in body temperature than do sleeping least chipmunks.

A method for determining relative ages of both species is presented. The method is based on tooth eruption.

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TABLE OF CONTENTS

INTRODUCTION

The lack of detailed study of North American chipmunks is surprising, considering their large geographic range, diurnal and usually conspicuous habits, and the ease with which most species become adapted to the presence of man. Howell (1929) provided the most extensive systematic study of the two genera (Tamias and Eutamias), summarizing existing knowledge of the biology of North American chipmunks and directing attention to the comparative paucity of information on these animals. After three decades, little more seems to be known of the life histories and physiology of most chipmunks, although books such as those by Seton (1909, 1929), Hamilton (1943), Cahalane (1947), Burt (1957), and Jackson (1961) contain much general information on the life histories of some species.

Of all the species of chipmunks, the eastern chipmunk (*Tamias striatus* L.) has received the most attention. Life history studies of this species by Allen (1938), Burt (1940), Blair (1942), Manville (1949), Yerger (1953, 1955) and Panuska and Wade (1957) are notable. The papers of Klugh (1923), Harper (1927), Schooley (1934), Condrin (1936), Damon (1941), Engels (1947, 1951), Panuska and Wade (1956) and Layne (1957) include nearly all other published information based on field studies of the eastern chipmunk.

The genus Eutamias has received less attention. The work of Broadbooks (1958) on the yellow pine chipmunk (_E. amoenus_ J. A. Allen) is the most comprehensive. Davis (1934), Gordon (1936), Holdenreid (1940), Aldous (1941), Criddle (1943), Miller (1944), Shaw (1944), Larrison (1947), Manville (1949), and Tevis (1953, 1955, 1956) have provided additional information on field aspects of the biology of species of _Eutamias_. However, the most widely distributed of all North American chipmunks, the least chipmunk (_E. minimus_ Bachman), has received ecological attention only from Aldous (1941), Criddle (1943), and Manville (1949).

Physiological investigations of chipmunks are few in number. Woodward and Condrin (1945), Lyman and Blinks (1959), and Panuska (1959) have provided the published knowledge of physiological aspects of the biology of the eastern chipmunk. Cade (1963) summarized the scattered observations on torpidity in chipmunks and conducted the only experimental work on torpidity in the genus _Eutamias_.

In the Itasca Park region of Minnesota the ranges of the eastern and least chipmunks overlap. The opportunity to observe and collect relatively large numbers of both species stimulated this study. Investigations were undertaken in the field and laboratory in order to compare several aspects of the ecology and physiology of the two species. White (1953a) placed the genera _Tamias_ and _Eutamias_ in the tribes Marmotini and Callosciurini respectively. He acknowledged the similarities in morphology, and often of habitat, that exist between the species of the two genera, but concluded that members of the two genera attained their present phenotypic similarity by convergent evolution in response to an assumed similarity in the environmental conditions to which the two ancestral lines were exposed during their evolution. Burt (1940) and others have noted the apparent similarity in habitat requirements of T. striatus and E. minimus in the Great Lakes area. Burt wrote, "Each of two species . . . . may appear fitted to live in both habitats, yet each remains in its own."

Since there is agreement that eastern and least chipmunks, despite the possible lack of a close phylogenetic relationship, are morphologically similar and seem to have broadly similar habitat requirements, questions may be raised concerning the extent to which the two species compete and about possible exclusion mechanisms that prevent further competition. "Competition" is used here as defined by Birch (1957), meaning the utilization of a limited resource by a group or groups of organisms, or the interference of one group with another in the act of obtaining a resource.

In this study, eastern and least chipmunks at Itasca Park were studied with regard to the following: 1) habitat preferences, 2) differences in habits, 3) size differences with regard to sex and age,

4) seasonal differences in age composition of the populations, 5) the emergence of young chipmunks aboveground, 6) incidence of reproductive activity in adults, and 7) food preferences. In the laboratory, studies of water economy, temperature regulation, and torpidity were conducted with the hope that the results obtained would be meaningful when applied to observations concerning the habitat and habits of the two species.

MATERIALS AND METHODS

Field Studies

From June through September in 1962 and from late May through early October in 1963, 215 eastern and 91 least chipmunks were collected by shooting, using .22 caliber shot shells, or snaptrapping with rat traps baited with peanut butter or chewed rolled oats or a combination of the two baits. All animals were collected within a 12-mile radius of Itasca State Park, Clearwater and Hubbard Counties, Minnesota. Traps were often tied to fallen tree trunks or branches. Aside from placement of traps where chipmunks were thought or known to occur, no special techniques were used to attract one species or the other. Hunting techniques differed for the two species. Eastern chipmunks were shot using one of three methods. In the early forenoon the animals were often seen in aspen trees and, if approached slowly, would remain quiet until I was within range (7-30 ft) of them. A second method was to walk along a road or path until a chipmunk was frightened from the roadside into the brush. A slow, quiet stalk toward the place where the animal's alarm call was last heard sometimes produced an opportunity for a shot. More often it did not, since the chipmunks often continued to run for some distance after their alarm calls ceased. If they remained motionless or hidden, they were very difficult to see. In the latter case, three to five minutes of silent waiting often produced a shot when the animal revealed itself by moving. A third method, also useful in the collection of least chipmunks, was to locate by ear a calling individual and then stalk it. The chipmunk would often sit and watch my approach until I was able to get within range.

In addition to the method just cited, least chipmunks were successfully hunted by watching the open areas the species frequents, then stalking individuals after they were seen.

Measurements of total length, tail length, hind foot length, ear length and weight were taken from the 215 eastern and 91 least chipmunks used in this part of the study. Head-and-body length was computed by subtracting the tail length from total length. Linear measurements were taken to the nearest millimeter by means of a transparent plastic rule. Weights were taken to the nearest 0.1 gram with an Ohaus triple-beam balance. Animals were frozen for several days to several weeks before being thawed, weighed, and measured. The skulls of all the animals were cleaned by boiling until the flesh was soft enough to be removed. Measurements of occipitonasal length and interorbital breadth (Fig. 1) were taken from the cleaned, dry skulls with a Helios dial caliper accurate to 0.1 mm. The arithmetic mean, standard deviation and standard error of the mean, and the coefficient of variation (V) were computed for the age and sex groupings of each species.

The relative age of each specimen was determined by examination of its upper molariform teeth (Fig. 1). Chipmunks designated as juveniles were those in which at least one of the upper third molars had not yet reached occlusal level. Subadult animals were those in which both upper third molars had attained occlusal level but in which at least one permanent upper fourth premolar was not yet at occlusal level. Adult chipmunks were those in which all the permanent upper teeth had attained occlusal level. Whether or not a premolar is deciduous may be determined by the pattern of wear on its occlusal surface (White, 1953b), or by the amount of wear on its occlusal surface relative to the amount of wear on the other molariform teeth. In a young animal, the deciduous premolars show more wear than do the molars. If the permanent premolars have erupted, however, they show less wear than do the molars. If additional evidence is needed, a small hole may be chipped in the maxillary bone at the base of the premolar or the tooth may be removed, exposing the permanent premolar, if present.

Incidence of reproductive activity was determined by examination of females for lactation or pregnancy, by examination of males for enlarged, scrotal testes, and by comparison of the relative ages of specimens with the semimonthly period in which they were captured.

The pouch contents, if any, of each animal were removed as the animal was skinned. In 1962, the pouch contents were sorted only according to the species of chipmunk from which they were taken. In 1963, each chipmunk's pouch contents were stored in an envelope labeled with the animal's collection number. The seeds were identified by Mrs. Frieda Wertman.

The stomachs of 170 eastern and 65 least chipmunks were preserved in formalin and later examined for the presence of animal matter, such as arthropod parts, flesh, feathers, etc., in their contents.

The pelts of 182 eastern and 73 least chipmunks were prepared as study skins. The skins, with the cleaned skulls, were deposited in the Minnesota Museum of Natural History. Thirty-one eastern and 14 least chipmunks were used in fat content determinations discussed later.

For each individual, data on species, sex, age class, date of capture, reproductive condition, occurrence of animal matter in stomach contents, and community type in which the animal was captured were recorded in writing and coded on key-sort sheets in order to facilitate recovery of information and searches for possible correlations among the data.

Statistical procedures followed were those of Simpson, Roe, and Lewontin (1960). The level of significance used for tests of hypotheses was 95%.

Laboratory Studies

Chipmunks for use in laboratory studies were captured in National Live Traps set at several localities in the study area. Traps 5 1/2 in. x 5 1/2 in. x

16 in. long were suitable for capturing both species of chipmunks. In 1962, seven eastern and nine least chipmunks were obtained. Two cages, each 2 1/2 ft x 2 1/2 ft x 4 ft long, were used to confine the animals, which were separated according to species. The animals were provided with wild bird seed, sunflower seeds, corn kernels (of which only the embryos were eaten), and Purina lab chow. Water was available in pans or graduated drinking tubes. Four least chipmunks died during the fall and winter of 1962-1963. No experimental work was done during this time.

Sixteen more eastern and 14 more least chipmunks were captured during June and July of 1963. Experimental work was begun in August. Until early December, only nine animals of each species were confined individually. Other animals were kept, according to species, in large cages. All cages were provided with wood shavings for litter. Sunflower seeds, Purina lab chow, and water were available. During the course of experimental work, temperatures in the animal room ranged from 80°F during August to 54°F during December. Humidity was neither controlled nor recorded. In late November, a time-clock was set to provide the animals with light from 6:00 AM to 6:00 PM daily. This schedule was maintained through March of 1964, when more than 12 hours of natural light were available.

The individually confined chipmunks were kept in metal screen cages, each marked with the occupant's species, sex, and an arbitrarily assigned number. The cages were approximately 18 in. x 18 in. x 12 in. deep. Only one individual of each species was removed from his cage at a time, in order to avoid placing an animal in the wrong cage.

By early December of 1963, 21 eastern and 11 least chipmunks remained alive. All were placed in individual cages. Each of the 11 least chipmunks was kept in an 18 x 18 x 12 cage, as were nine of the eastern chipmunks. The remaining 12 easterns were placed in slant-front cages with a maximum depth of 11 in. and a floor 12 in. x 15 in. The cages were cleaned, and additional litter, food, and water provided, as needed.

During the experiments on water consumption nine eastern and nine least chipmunks, individually confined in 18 x 18 x 12 cages, were fed only sunflower seeds. Water was provided in 30 cc or 100 cc graduated drinking tubes. One tube of each size was hung on the rack of cages in order to permit assessment of evaporative water loss from the tubes. For 36 days daily records were kept of the change of water level in each animal's drinking tube and in the control tubes. On 18 days at least one eastern chipmunk spilled water from its tube, as indicated by wet litter below the tube. Least chipmunks were never known to spill water from their drinking tubes. Records of water consumption for the 18 days on which no spillage was noted were used to calculate each chipmunk's water consumption. The total amount of water each animal consumed during the 18 days was divided by the mean value of the animal's body weight as recorded on the first and thirty-sixth days. The resulting figure was the amount of water each chipmunk drank per gram of body weight during the 18 days considered. The figure was divided by 18 in order to determine the mean water consumption per gram of body weight per day. Each animal's total water consumption during the 18 days was divided by 18 to determine the individual's mean daily water consumption. The arithmetic mean, standard deviation and standard error of the mean, and coefficient of variation (V) were computed for each of the foregoing values for each species.

Rates of weight loss during water deprivation and weight gain during rehydration were determined. Of the nine individuals of each species, seven were deprived of water for five days. Two individuals of each species were used as controls and were allowed unrestricted access to drinking water. The chipmunks were weighed on an Ohaus triple-beam balance accurate to 0.1 g at intervals of 24 hours ± one hour during the five days of water deprivation and for seven days after access to water was restored. Each animal's daily weight was recorded as a percentage of its weight at the beginning of the experiment. Mean daily percentages were calculated. During this experiment the chipmunks were fed only sunflower seeds.

Rectal temperatures of chipmunks in various states of physical activity were determined by means of a type TP-3, 16 gauge hypodermic needle probe attached to a Tri-R Tempcord-R thermometer calibrated to a mercury-in-glass thermometer tested by the U. S. Bureau of Standards. The probe was inserted rectally to a depth of 30 to 35 mm to obtain each temperature reading. Animals were classified as sleeping if they were sleeping when taken from their cages, as resting when awake but sitting quietly when taken, or as active if they moved about for more than a few seconds before being caught. Some animals were forced to run for five or six minutes before their temperatures were recorded. The temperatures of chipmunks found sleeping or torpid (in late December) and of active chipmunks (May) were chosen for study.

Two attempts were made to induce torpor in chipmunks by keeping them in a refrigerator at 3-4°C or 9-10°C. Some animals were provided with food and water; others were not. The animals were kept in the refrigerator for 24 to 72 hours.

Water and fat were extracted from 34 eastern and ten least chipmunks. To hasten dehydration, the large muscles of each weighed, skinned carcass were slit in several places; the bones were broken with a small hammer. The macerated carcass and the skin were placed in a weighed extraction thimble and desiccated in an oven at 105°C until the combined weight of the thimble and carcass were identical on two successive days.

This weight, less the original weight of the thimble, was recorded (to the nearest 0.1 g) as the dry weight of the chipmunk. The percentage of water in the carcass was then computed. The desiccated carcass was ground in a food chopper and the ground tissue was replaced in the extraction thimble. The ether-soluble material was removed in a Soxhlet extraction apparatus. Extractions were carried out for 96 hours to six days, although all the ether-soluble material was found to be removed during the first 96 hours of extraction. The previously weighed flask in which the ether and solute accumulated was allowed to stand, following extraction, until the ether evaporated. Then the flask with the solute (assumed to be lipid) was oven-heated to 90°C to drive off any water that might have accumulated in the flask. When a constant weight of flask and lipid were achieved on two successive weighings (about 12 hours apart), the weight and percentage of lipid in the specimen could be determined.

Statistical procedures followed were those of Simpson, Roe, and Lewontin (1960). The level of significance used for tests of hypotheses was 95%.

RESULTS

Field Studies

Although trapping and hunting were concentrated in areas where observation or previous collecting showed relatively large numbers of chipmunks to be present, nearly all types of terrestrial habitats in the study area were trapped at least once. Trapping and hunting in spruce-fir forest produced no chipmunks. Collecting in maple-basswood stands produced a few eastern, but no least chipmunks. Red and white pine stands, except when in proximity to disturbed areas, produced only eastern chipmunks. Aspen and jack pine stands supported the largest numbers of eastern chipmunks. Disturbed areas, such as deserted gravel pits, farms, clearings, active and deserted logging sites, lumber mills, power line clearings, and rock piles, surrounded by aspen, jack pine, or red and/or white pine supported the greatest numbers of least chipmunks. In the woods-edge surrounding such areas both least and eastern chipmunks were taken. Thus, it appears that, as the literature suggests, chipmunks are animals of disturbed areas or forested lands in the early stages of succession. Of the two chipmunks, leasts were far more common in open situations than were easterns. For example, the largest series of least chipmunks was collected on a large slash pile surrounded by a dense ring of raspberry bushes (Rubus minnesotanus) which, in turn, was surrounded by young aspen. Least chipmunks were shot only in the open, on the slash, in the raspberry bushes, or in the clearing leading to the slash pile. Eastern chipmunks were never seen on the slash pile. A very few were collected in the aspen immediately adjoining the clearing. In another area about 1/2 mile away, numerous small slash piles were scattered on a slope above a thickly wooded, nearly dry bog. Here, young aspen grew between the piles, most of which were shielded from open sky by foliage. Least chipmunks were shot in large numbers only on the largest and most open of the piles. Eastern chipmunks were seen and collected in the young aspen and on and at the margins of the smaller piles. Many easterns, but no leasts, were seen, heard, and collected in the young aspen beside the abandoned road that led to the two slash areas. In a dozen visits to an access road to Beauty Nest Lake, south of Itasca State Park, many eastern chipmunks were collected in the dense hazel understory of a mature aspen forest through which the road ran. Only one least chipmunk was trapped, and no others seen or heard along this two mile road. At a deserted gravel pit near LaSalle Springs, within Itasca State Park, trap lines were run along the edge of the pit and into a jack pine stand that surrounded the pit. There was a thick hazel understory in this stand. Although several least chipmunks were captured, along with many easterns, in traps tied to fallen jack pines aroung the pit margin, captures from within the stand were exclusively eastern chipmunks.

The general picture of habitat preference that emerged was as follows. Neither species of chipmunk was found in large numbers in spruce-fir, maple-basswood, or red or white pine stands. Both were found in jack pine and aspen forests and at the edges of these and red and white pine stands. Of the two species, _T. striatus_ seemed more retiring and only rarely ventured out from under vegetative cover. Eastern chipmunks were seen foraging 6-20 ft up in young or mature aspen trees and in hazel shrubs. In contrast, least chipmunks were often found on slash, brush, and rock piles 40-50 ft from vegetative cover. Within the study area I found hazel brush to be a reliable indicator of eastern chipmunks. An open forest margin with rock, brush, or slash piles interspersed with raspberry thickets was favorable habitat for least chipmunks, at least during the summer.

Daily activity patterns of both species showed some variation. Relatively few animals were caught on rainy or windy days. Greatest activity was noted on bright, warm, quiet days. Eastern chipmunks were active slightly earlier than were the leasts and were often seen foraging in trees by 7:00 AM CST in late June and through July. By mid-morning, eastern chipmunks' activity decreased and then increased again after mid-afternoon. They remained active until it was nearly dark. Greatest numbers of least chipmunks were heard, observed, and collected between 8:00 AM and

11:00 AM and 2:00 PM and 5:00 PM CST. However, if least chipmunks were abundant in an area, some could be seen at any hour between 8:00 AM and dusk. Eastern chipmunks were frequently seen basking in late afternoon. Least chipmunks basked and groomed themselves in the morning.

In order to assess the presence and abundance of each species of chipmunk in a given area, it was necessary to learn the differences in their call notes. Both species have three basic notes. The alarm call is a shrill chir-r-r often prolonged, with some interruptions, as the animal flees. The "chip" note is often heard as the animal sits on a perch and watches things about him. Seton (1909) recorded an eastern chipmunk that produced 130 "chip" calls per minute for 11 minutes. I mimicked the "chip" note by smacking my lips on the back of my hand. The third call is a soft, musical "chunk", repeated as is the "chip". The "chunk" note was mimicked by a short, soft whistle. The least chipmunk's utterance of all three calls is several steps higher than that of the eastern; the difference was so marked that I did not need to hear both calls at once to distinguish them from each other. The "chip" note of the least, in addition to being the more highly pitched, often gives the listener the impression that the sound is being hurled from the animal's body. The note might be written, "pwERT." To my ear, the "chunk" note of the least chipmunk is more musical than that of the eastern.

Juvenile eastern chipmunks were found to be significantly smaller ($P = 0.05$) than subadults of that species in all size measurements considered (Fig. 2, Tables 1-8). Subadult eastern chipmunks were found to be significantly smaller than adults (Fig. 2, Tables 1-8). Within any age class, no significant differences were found between the two sexes. The males and females of any age class were significantly different in size from the males and females of the other age classes, except that no significant difference was found between the hind foot lengths and interorbital breadths of juvenile and subadult males and juvenile males and subadult females (Tables 3, 8, 17).

Juvenile least chipmunks were significantly smaller ($P = 0.05$) than subadults of that species in all size measurements considered except tail and ear lengths (Fig. 3, Tables 9-16). Subadult least chipmunks were significantly smaller than adults in all size measurements but tail and ear lengths (Fig. 3, Tables 9-16). Within the subadult age class no significant size differences between the sexes were found. However, adult males were significantly smaller than adult females in total length, head-and-body length, and body weight. The comparisons of subadult males and females with adult males and females showed no significant size differences between the various groups in 19 of 32 comparisons (Table 18). Due to the small number of juvenile least chipmunks captured, no comparison of size between the sexes or between them and the sexes of other age classes was attempted.

The young of eastern chipmunks appeared aboveground in late June, about two weeks earlier than the young of the leasts (Figs. 18-23, Tables 19, 20). No individuals of either species were found to be in any sort of active reproductive condition--pregnant, lactating, or with enlarged, pendulous testes--later than early July (Tables 19, 20).

The results of studies of pouch contents of both species of chipmunks are summarized in Table 21. The results of examination of stomach contents of the chipmunks are summarized in Tables 22-24. The animal matter most commonly found in stomachs was arthropod remains--e.g., fragments of legs, antennae, elytra, and even nearly complete animals such as ants. The stomachs of four juvenile easterns, one subadult least, and one adult eastern contained feathers in addition to arthropod parts. The stomach of one subadult eastern contained feathers, but no other animal matter. The stomach of one adult eastern contained, in addition to arthropod remains, some patches of skin with hair attached to it. The stomachs of two adult eastern chipmunks contained muscle and tendon. It should be noted that within each species, the proportion of stomachs containing animal matter was not significantly greater in one age class than in any other (Table 24). Within a given age class the proportion of eastern chipmunk stomachs containing animal matter was always highly significantly greater than that for least chipmunks of the same age class (Table 24).

Laboratory Studies

The results of studies of water consumption by the two species of chipmunks are shown (Tables 25, 26); standard deviations and standard errors of the means are presented (Tables 27, 28). All relative values of water consumption were lower for least chipmunks than eastern chipmunks, but not significantly so. Gross water consumption was greater in the larger species.

There was no significant difference between the two species in their ability to resist weight loss during water deprivation or gain weight once access to water was restored (Fig. 24, Tables 29, 30).

Results of studies of rectal temperatures of sleeping and active chipmunks are summarized in Table 31. No significant difference was found between the rectal temperatures of active eastern and least chipmunks. No significant difference was found between the rectal temperatures of sleeping eastern and least chipmunks, but the temperatures of the sleeping eastern chipmunks were much more variable than were those of the leasts.

Attempts to induce torpor experimentally were not successful with either species of chipmunk. However, some animals kept in the animal room at ambient temperatures of 15 to 20°C became torpid for several hours to several days at a time during late November, December, January, and February. Of 21 eastern chipmunks, 19 became torpid at least once during the winter. Only one of 12 least chipmunks became torpid at any time. All of the eastern chipmunks that became torpid were very fat. When torpid, they were unresponsive to touch, very stiff in their movements when handled, and had rectal temperatures only slightly above the ambient temperatures. The animals opened their eyes when rectal temperatures reached 17 to 22°C. Well-coordinated activity was not observed until rectal temperatures were above 30°C. The rates of arousal from torpor of five eastern chipmunks are shown in Figure 25.

One eastern chipmunk, having become torpid in the animal room, was transfered to the refrigerator at 5°C. When arousing this animal opened its eyes when its rectal temperature was 14°C. The chipmunk was capable of well-coordinated movement at about 27°C. Its rectal temperature was 10°C when the animal was removed from the refrigerator to a warm room (22°C). The rates of arousal of this chipmunk and of the only least chipmunk to become torpid are shown in Figure 26.

On November 8 at 2:00 PM a female least chipmunk was found torpid in her cage. She did not react when touched and had consumed only 7.6 cc of water since November 4, when she was last examined. Her breathing was timed at ten breaths per minute; five breaths were taken in one ten-second period. Between 3:55 PM and 4:05 PM she shifted position several times and began to breathe more rapidly (75-80 bpm), though still irregularly. At 4:07 PM, when it appeared definite that the animal was arousing, her rectal temperature was 27°C. Taking her temperature may have furnished a further s timulus to arousal, because after the first temperature reading she shivered violently, moved about the cage when touched, and awakened rapidly.(Fig. 26).

Extraction of fat from 34 eastern and 10 least chipmunks suggested no significant increase in fat in these species during the late summer and early fall. Tevis (1955) found that three species of Eutamias in California did not become fat until just before they disappeared underground for the winter. Thus, it is possible that my small samples from that critical time may not reveal an actual difference in the amount of fat accumulated by the eastern and least chipmunks.

DISCUSSION

There are apparently some differences between the forest types inhabited by the least and eastern chipmunks in different parts of their geographic ranges. Authorities agree, however, that both species avoid thick unbroken forests (Seton 1909, 1929; Hamilton 1943; and others). Burt (1957) wrote that in the Great Lakes area eastern chipmunks occur in hardwood forests and semi-open brushlands; leasts occur in cedar, spruce, and hemlock forests, semi-open country, and around abandoned buildings. Jackson (1961) found eastern chipmunks common in deciduous forests, least chipmunks in coniferous and mixed forests. Gunderson and Beer (1953) stated that least chipmunks in Minnesota occur primarily in the coniferous forest zone whereas eastern chipmunks occur primarily in the deciduous forest zone. Manville (1949) studied the forest types in which several small mammalian species were found in the Huron Mountains of Michigan's upper peninsula. Unfortunately, his studies did not include aspen or red or white pine stands. My findings agree that maple-basswood forests support few eastern chipmunks and no leasts, and that jack pine stands support large numbers of eastern and least chipmunks within and/or around their borders. However, my findings differ in that Manville found least chipmunks in swampy habitats (black spruce and northern white cedar swamps) and I did not. I frequently found eastern chipmunks in woods at the margins of bogs and lakes. This is in contrast to the statements of Seton (1909, 1929) and Manville (1949), who wrote that dryness is important in the distribution of eastern chipmunks.

The large numbers of least chipmunks I found near aspen stands seem to contradict the statements that least chipmunks occur mostly in coniferous forests. However, aspen stands at Itasca are often found on areas of former pine stands that were logged. Tevis (1956) found that the numbers of E. townsendi increased when logging permitted the growth of herbaceous and shrubby vegetation. It seems reasonable to assume that logging in northern Minnesota may have had a similar effect on the numbers and distribution of E. minimus. It also seems reasonable that the subsequent growth of aspen or jack pine on a logged or burned area probably allows the invasion of eastern chipmunks into the actual reforested area, while least chipmunks continue to occupy the open forest edges.

Burt (1940) wrote, "(T. striatus) rarely is seen at any distance from wooded or brush-covered areas. They always seem to desire a protective cover and certainly are not at home in the open." Hamilton (1943) wrote that least chipmunks are not found in thick evergreen forests; they frequent timbered areas less than does T. striatus. He listed forest borders, shore lines, cliffs, and open jack pine as least chipmunk habitat; open woods and thick underbrush were cited as preferred eastern chipmunk habitat. Manville (1949) concluded that deep shade and a dry habitat were critical in the distribution of T. striatus. He found eastern chipmunks in heavy cover, while nearby unshaded openings harbored least chipmunks. He concluded, "[E. minimus] seems to be but slightly influenced in its distribution by dense cover or moisture."

My findings suggest that in the Itasca Park region, T. striatus is limited to areas of tree cover but E. minimus is not. Some eastern chipmunks were found in very moist situations, whereas least chipmunks were found in greatest abundance in such relatively dry areas as gravel pit margins and slash piles. Burt (1940) suggested that psychological reasons may underlie an animal's selection of habitat--i.e., an animal may feel more "secure" in its own habitat than elsewhere. Regardless of other ecological and psychological reasons underlying the differences in selection of habitat by eastern and least chipmunks, it appears that the least chipmunk is better adapted to living an exposed existence than is its larger relative. The least chipmunk is smaller, darker, more agile, and relative to its size, faster than the eastern. In a bare room 7 ft x 7 ft I was able to capture eastern chipmunks by hand in about 1/3 the time required to capture leasts. A small, dark, fleet and agile animal could more readily elude a predator and hide in a slash or rock pile than could a larger, slower, and more conspicuous species. Thus, the greater agility, smaller size, and darker color of the least chipmunk may be of adaptive value in allowing the species to avoid predation in its exposed habitats. Conversely, the smaller species may have difficulty in moving on the herb and litter-covered floor of the forests preferred by the larger eastern chipmunk. Even beyond the overlap of its range with that of _T._ _striatus_ and other chipmunks, _E._ _minimus_ seems to avoid dense tree cover. Baker (1951) recorded that Alcorn found _E._ _m._ _caniceps_ occupying abandoned road camps along the Alaska Highway in greater numbers than in undisturbed natural habitat.

Concerning daily activity, Allen (1938), Burt (1940, 1957), and Jackson (1961) found, as I did, that eastern chipmunks are most conspicuous in early forenoon and late afternoon. Jackson (1961) wrote that least chipmunks were most conspicuous in the sunny hours of midday; again, my observations agree. Broadbooks (1958) found, however, that _E._ _amoenus_ was active in early forenoon and late afternoon but retired during the oppressive midday heat. It is probable that midday summer temperatures in the Itasca Park region are less severe than in Broadbooks' study area in eastern Washington. This might account for the observed differences in hours of activity of _E._ _amoenus_ and _E._ _minimus_.

The statistically significant size differences I found between the three age classes of both species of chipmunks lead me to believe that my method of determining relative ages is valid. If so, my data may be helpful to future investigators concerned with estimation of relative ages of living chipmunks. Unfortunately, the measurement most easily taken on a living small mammal is body weight. Tevis (1955) found weight an unreliable indicator of age in four species of Eutamias in California, owing to variation in amount of food in the animals' digestive tracts. However, Figures 7 and 15 show that, although the ranges of body weights of my specimens in different age classes overlap, there is no overlap of the means plus and minus one standard deviation between any of the age groups of either species. Thus, one has at least statistical assurance of the range in weight of 2/3 of the population in a given age class.

It is of interest to attach some chronological age to the relative age classes I have erected. For T. s. lysteri in New York, Allen (1938) and Yerger (1955) have provided data on the time required for the development of various stages of dentition. Using their criteria, my juvenile eastern chipmunks would be between four and ten weeks old; subadults would be between ten and 13 weeks old. I found no similar reference work on E. minimus or other species of Eutamias. However, one might expect that the time required for each stage of dental development would be slightly less than for _T. striatus_.

The statistically significant difference in some size measurements between adult male and adult female least chipmunks (Fig. 15, Table 14)deserves comment. Howell (1929), Jackson (1961) and others have stated that no significant variation in size owing to sex is known to occur in any species of chipmunk. Broadbooks (1958), however, found statistically significant differences between the live weights of breeding and non-breeding females, adult males and non-breeding females, and male young and female young as the animals approached adulthood. He also found that the weights of animals he captured in 1947 were significantly greater than those of animals captured in the same place and at comparable dates in 1946. He hypothesized that severe winter conditions in 1946 may have affected weights by affecting food quality and date of emergence of the chipmunks from hibernation. Thus, from this work and that of Tevis (1955), it appears that not too much importance should be attached to the difference observed in weights of adult male and female least chipmunks. There is no obvious explanation for the difference in total length and head-and-body length between the sexes. It is noteworthy, however, that there is no significant difference between the sexes in either of the two skull measurements considered. Skull measurements are thought to be less subject to environmental influence than are external measurements.

The work of Seton (1909, 1929) in Connecticut, Allan (1938) and Yerger (1955) in New York, Condrin (1936) in Ohio, Schooley (1934) in Indiana, Panuska and Wade (1957) and Jackson (1961) in Wisconsin, and Burt (1940, 1957), Blair (1942) and Manville (1949) in Michigan shows the eastern chipmunk to have two breeding seasons per year in those states. Only Manville (1949) showed evidence of two breeding seasons per year for E. minimus; Burt (1957) left the question unanswered. Seton (1909, 1929), Jackson (1961) in Wisconsin, and Criddle (1943) in Manitoba presented no evidence of two annual breeding seasons for E. minimus. Gunderson and Beer (1953) wrote that T. striatus has two annual breeding periods, and that E. minimus may have two, in Minnesota. Howell (1929), Tevis (1955, 1956) and Broadbooks (1958) found no evidence of a second annual breeding season in other species of Eutamias.

It is, of course, easier to demonstrate the occasional occurrence of a second annual breeding season than to prove it does not exist. My data on the age classes and reproductive conditions of chipmunks captured during 1962 and 1963 do not suggest a second annual breeding season in the Itasca Park area for either eastern or least chipmunks. However, the absence from late-summer samples of males with pendulous testes, pregnant and lactating females, and animals from the juvenile age class, together with the general increase in size of subadults and the fact that relatively few chipmunks were caught late in the summer, militate against the possibility of a second annual breeding season for T. striatus and E. minimus in northwestern Minnesota. The possibility, suggested by Allen (1938), Jackson (1961), and others, that a given female may breed again following the loss of a litter, is not refuted. I found no evidence in the field or recent literature to support the conjecture of Seton (1909, 1929) that female chipmunks may be inseminated in the fall and bear the resulting young the following spring.

Of interest is the approximately 15-day lag between the appearance aboveground of juvenile eastern and juvenile least chipmunks. If there were competition between the two species, it would probably be most intense when their young emerge and begin to forage for themselves. If this were the case, a difference in dates of the emergence of the young of the two chipmunks might be of adaptive value.

Since local floras differ, the studies of workers on food habits of chipmunks in one area have limited application in other areas. The reader is referred to Klugh (1923), Seton (1929), Allen (1938), Criddle (1943), Tevis (1953, 1956), Yerger (1955), and Jackson (1961) for information on the food of chipmunks in various areas. Aldous (1941) studied the food of least chipmunks near Ely, in northeastern Minnesota. My data suggest that in the Itasca Park area there is little competition between eastern and least chipmunks for food (Tables 21-24). The differences between the kinds of seeds and the abundance of animal matter collected by the two species of chipmunks are striking.

Although the reasoning may be circular, it is interesting to note that the habitats occupied by the seed species collected by the two chipmunks are correlated with the habitats where each chipmunk was found. The correlation suggests that the differences observed in the habitats of the two chipmunks are real.

Allen (1938) wrote that animal matter composed only a small part of the diet of eastern chipmunks in New York state. However, more recent work (Aldous 1941, Hesterburg 1950, Morris 1953, Tevis 1953, 1956, and Yerger 1955) have demonstrated a high frequency of consumption of animal matter by chipmunks. To what extent eastern and least chipmunks compete for animal food in uncertain. However, one may infer from their differences in habits and habitat that they compete but little, if at all, for animal matter.

The problem of water balance in chipmunks has not received much attention from physiological ecologists, although there are a few references to water consumption in North American chipmunks. Allen (1938) wrote, "Unlike many of the Western ground squirrels, the Eastern chipmunk requires a great deal of water to drink." Panuska and Wade (1957) found the water consumption of captive T. striatus decreased from 33.4 ml per day just after capture to 29.2 ml per day after the animals had been confined for a time. Other references are less direct. Seton (1929) observed that west and south of Manitoba, E. minimus, ". . . is found in wastes of sage and rock, remote from any water supply . . ." Howell (1929) pointed out the variation in habitats occupied by chipmunks and observed that one species (E. merriami) has a race in the more arid southwestern deserts. Davis (1934) wrote that water was not a factor in determining the distribution of E. dorsalis in Nevada. Manville (1949) found water to be of little importance in the distribution of E. minimus in Michigan's Huron Mountains.

The picture that emerges from the literature is that eastern chipmunks are more dependent upon a plentiful source of drinking water than are least chipmunks and their relatives. The present experimental work suggests that this is true even though the least chipmunk is more active and has higher metabolic* and breathing rates than the eastern chipmunk has. One would expect that least chipmunks would require relatively more water than the larger eastern species, but tests of water consumption and rates of dehydration and rehydration revealed no significant difference between the water economy of the two species. The gross water requirements of E. minimus are about 1/3 of those of T. striatus. This difference alone may enable least chipmunks to exist relatively independently of standing

*--Metabolic rates estimated from the formula of Kleiber (1947, 1961).

water.

From the writings of Hamilton (1943) and others, and from my own collecting success (Tables 19, 20), it appears that E. minimus retires underground somewhat later in the fall and emerges somewhat later in the spring than does T. striatus. This may account for the observed two-week difference between the appearance of the young of the two species. Although Seton (1929) wrote that weather alone caused T. striatus to hibernate, recent work suggests that temperature alone is relatively unimportant in determining the hibernation time of chipmunks. Allen (1938) concluded from her studies of T. s. lysteri that, ". . . the hibernation of chipmunks is extremely variable and certainly not controlled by external agencies alone." She also believed that awakening from hibernation in the spring was controlled by the condition of the gonads of the chipmunks. Engels (1951) found evidence in T. striatus to suggest, ". . . the existence of an inherent annual cycle [of winter inactivity] more or less independent of environmental conditions . . ." Tevis (1955) concluded that duration of hibernation at each locality is adjusted to average weather conditions and thus is independent of the year-to-year variations in weather. My observations in the field and laboratory also suggest that the disappearance and hibernation of T. striatus and E. minimus are relatively independent of weather and temperature. As has been pointed out, field trips in late September of 1962 and early October of 1963 provided only six least chipmunks (one live-trapped) and one eastern, despite sunny days with air temperatures in the 70-90°F range. Mr. Ray Glasco, a fire warden and farmer at Lower LaSalle Lake, north of Itasca Park, said that chipmunks usually begin to disappear from his grounds in mid-September. He offered the opinion that by that date the animals' food stores are laid in and, since they need not gather more food, their activity aboveground is reduced and less conspicuous. Early retirement underground might be of adaptive value to chipmunks, since underground they would be safe from sudden adverse weather and from predation.

Woodward and Condrin (1945) found the body temperatures of active eastern chipmunks to range between 35.8°C and 39.0°C, with a mean value of 37.5°C. Kendleigh (1945) reported the range of six rectal temperature observations on _T. s. lysteri_ as 36.5-40.1°C, with a mean of 38.6°C. Panuska (1959) found the range of 52 observations on 13 _T. striatus_ at at ambient temperature of 20°C to be 35.0-41.1°C, with a mean of 38.5°C and a standard deviation of 1.17°C. Cade (1963) provided records of body temperature for three species of _Eutamias_. At ambient temperatures of 10-20°C, he found rectal temperatures of _E. amoenus_ (a species nearly the same size as _E. minimus_) to vary between 37°C and 42°C in the active range, 35 and 38°C in the resting range, and 31 and 36°C in the sleeping range. At ambient temperatures of 3-4°C, Cade recorded rectal temperatures of 31-37° for resting and sleeping E. amoenus; a torpid E. amoenus had a rectal temperature of 4°C.

My records of body temperatures of active eastern chipmunks are higher than those of Kendleigh (1945) and Woodward and Condrin (1945), perhaps because the animals were forced to run for 2-6 min before their temperatures were taken. My observations on E. minimus are comparable to those of Cade (1963) for E. amoenus. The results of this work do not refute Rodbard's (1950, 1953) contention that weight and body temperature bear a direct relationship to each other in mammals weighing less than one kilogram, since the chipmunks were not in comparable physiological states when their temperatures were recorded. Rodbard stipulated that only basal temperatures afforded valid comparisons between species. The lower and highly variable temperatures I recorded in sleeping T. striatus suggest a poorer capacity for maintenance of constant body temperature than is found in E. minimus. The difference may be related to differences in hibernating ability of the two chipmunks.

The laboratory observations suggest that, although both species of chipmunks show individual variation in hibernating ability, the eastern chipmunk hibernates more readily than does the least. The work of Allen (1938), Woodward and Condrin (1945), Yerger (1955), Tevis (1955), Panuska (1959), Panuska and Wade (1960), and Cade (1963) offers evidence for variability in depth of torpor in both genera of chipmunks. Condrin (1936) thought the variability in depth of torpor in _T. striatus_ was a reflection of individual and seasonal variation in endocrine function. His hypothesis was supported by the work of Woodward and Condrin (1945). Latitude may affect depth of torpor in _T. striatus_ (Seton 1909, 1929) and other species. Criddle (1943), however, found _E. minimus_ in southern Manitoba occasionally active during every month of the winter. Svihla (1936) and Broadbooks (1958) found _E. amoenus_ in Washington occasionally active throughout the winter. Cade (1963) had only limited success in inducing torpor in _E. amoenus_. He concluded that that species, and perhaps others, depended chiefly upon its food stores for winter survival, but that hibernation was an alternative. Indirect support for Cade's argument may be inferred from the observations of Walker (1923) and Anthony (1924), who found _E. amoenus_ in deep winter torpor in dens lacking food stores. Lyman (1954) found that denial of food for storage prevented golden hamsters from entering hibernation. It seems reasonable that the abundance of stored food probably plays an important part in the onset and continuation of hibernation in chipmunks.

Captive _T. striatus_ became very obese as fall approached, but I was not able to demonstrate a similar accumulation of fat in captive least chipmunks or in wild chipmunks of either genus. Moreover, although Tevis (1955) found that three species of *Eutamias* accumulated some hibernation fat just before their fall disappearance, it is generally conceded that chipmunks rely principally on stored food for their winter diet. Neither Tevis (1955) nor Broadbooks (1958) could demonstrate fall fat accumulations in *E. amoenus*. However, there is a suggestion of some fat accumulation in the two *E. minimus* I captured in early October. Tevis (1955) found the period during which a fat chipmunk could be found was very brief. The lone eastern chipmunk I captured in October had a very low fat content, a fact which may account for this animal being active when, so far as I could determine, all other eastern chipmunks were underground. Panuska (1959) found evidence of an inherent annual weight cycle, characteristic of hibernators, in captive *T. striatus*. No comparable work has been done on *E. minimus* or other species of *Eutamias*. However, my laboratory records and observations lead me to believe that *T. striatus* has a greater inherent ability to accumulate fat in late summer and fall than has *E. minimus*. It is of interest to note that captive *T. striatus*, though obese in the fall and early winter, lost weight as spring approached. In April, they appeared to be nearly as trim as when they were captured.

CONCLUSIONS

The results of this study lead me to conclude that in the Itasca Park region of Minnesota the eastern and least chipmunks are distinct from each other ecologically. They appear to differ from each other in: 1) habitat, 2) daily and seasonal activity patterns, 3) time of appearance aboveground of the young, 4) food habits, 5) gross water requirements, and 6) ability to enter hibernation. They probably differ from each other in the time of onset of reproductive activity and perhaps in the ability to accumulate hibernation fat. The two species do not appear to differ significantly from each other in relative water requirements or in active or sleeping body temperatures, although the temperatures of sleeping eastern chipmunks were much more variable than were those of leasts.

The method I used for determining relative ages of the chipmunks seems to be valid. It may be useful in determining relative ages based on measurements that can be taken from living chipmunks.

GENERAL EXPLANATORY NOTES FOR FIGURES AND TABLES

J = juvenile, SA = subadult, AD = adult. Linear measurements are in millimeters. Unless stated to be expressed as percentages, all weights are in grams.

In Figures 2 through 17, the ends of the basal horizontal lines represent the extremes of the sample ranges. The mid-vertical lines represent the arithmetic means of the samples. The outer ends of the dark rectangles enclose each mean plus and minus two standard errors of the mean. The outer ends of the open rectangles enclose each mean plus and minus one standard deviation of the mean.

Other explanations accompany the figures in question.

Figure 1. Lateral and dorsal views of a chipmunk skull (after Hall and Kelson, 1959). The measurements and dental characteristics used in the study are indicated; a = occipitonasal length, b = interorbital breadth, P3 and P4 are the third and fourth upper premolars, respectively, and M3 is the upper third molar.

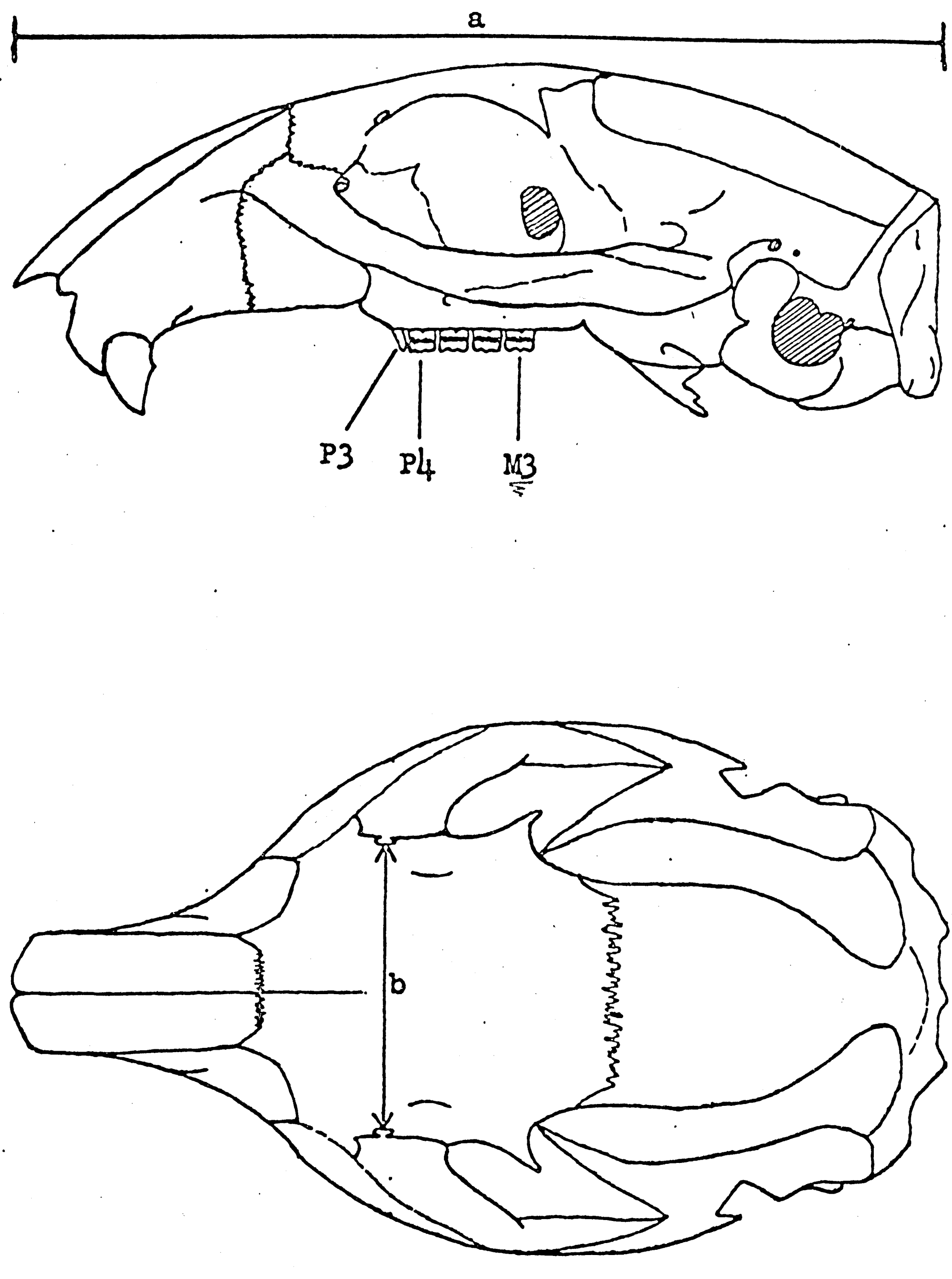

Figure 2. Comparisons of total lengths of groups of eastern chipmunks.

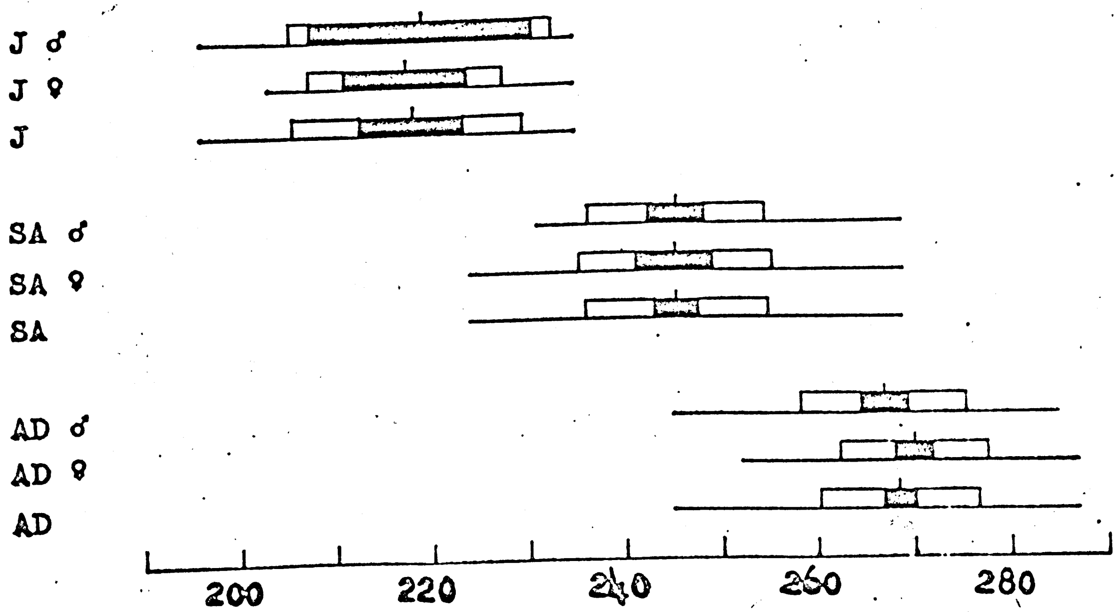

Figure 3. Comparisons of tail lengths of groups of eastern chipmunks.

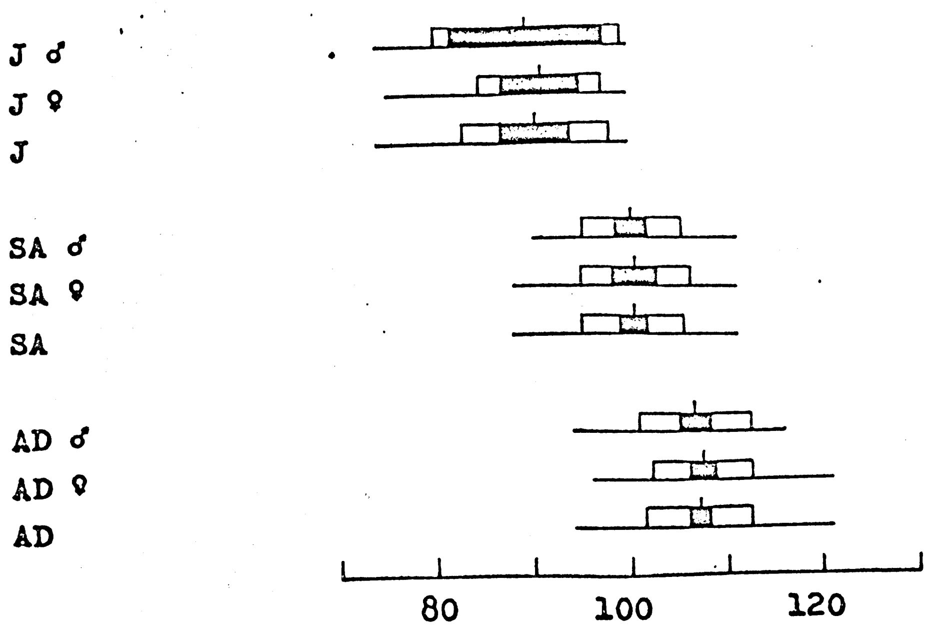

Figure 4. Comparisons of hind foot lengths of groups of eastern chipmunks.

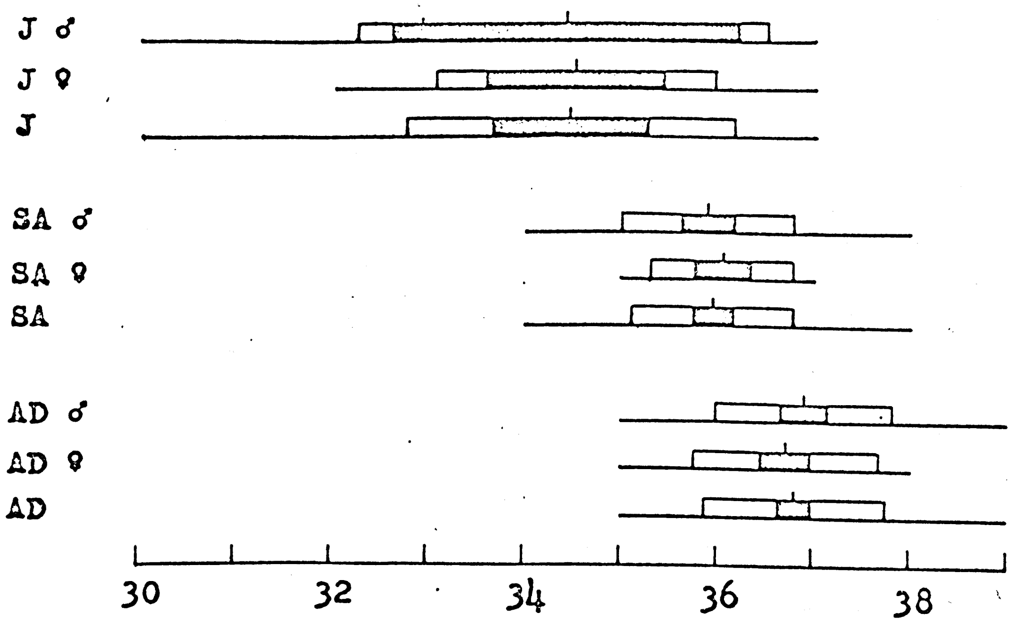

Figure 5. Comparisons of ear lengths of groups of eastern chipmunks.

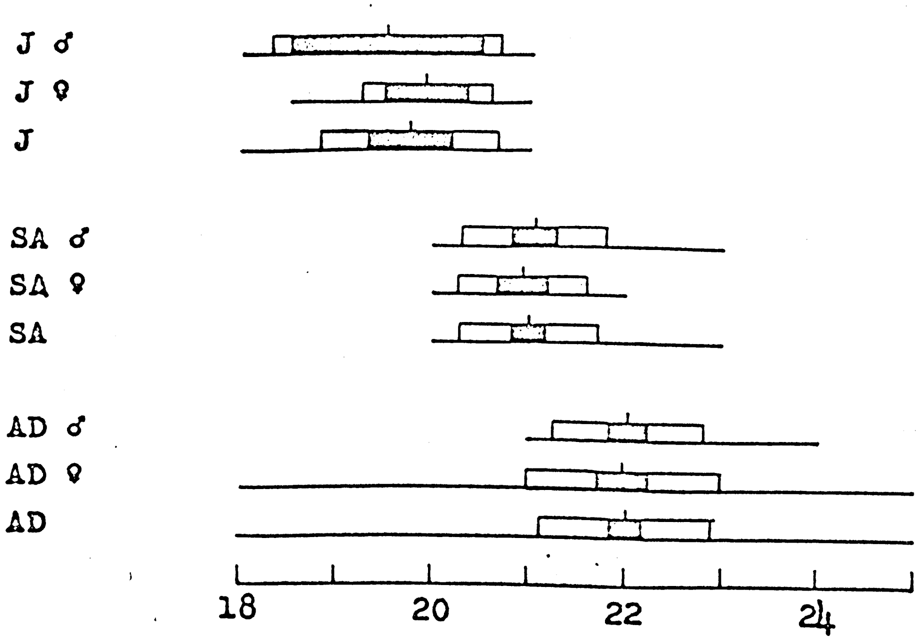

Figure 6. Comparisons of head-and-body lengths of groups of eastern chipmunks.

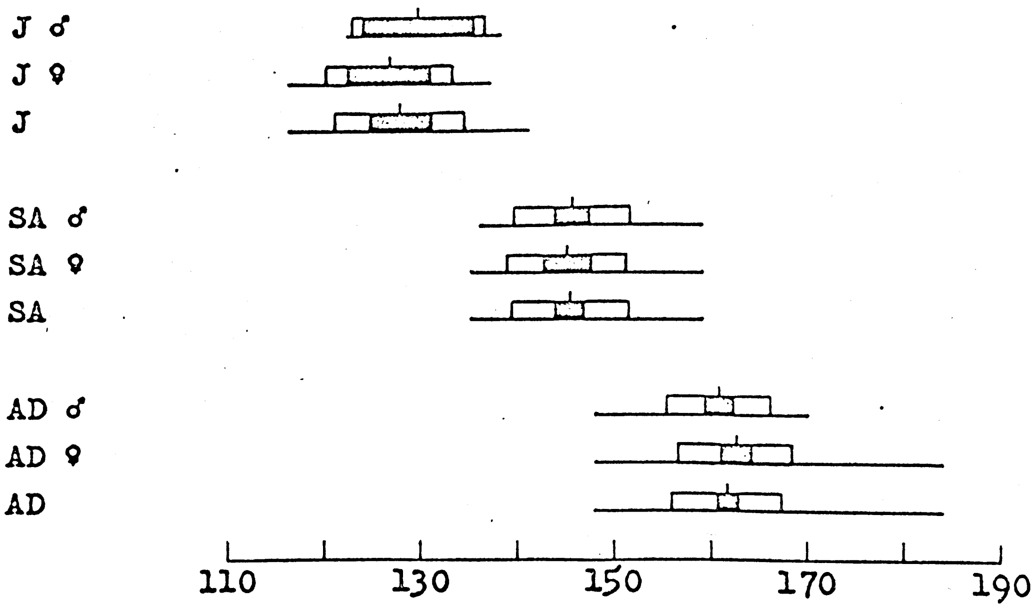

Figure 7. Comparisons of body weights of groups of eastern chipmunks.

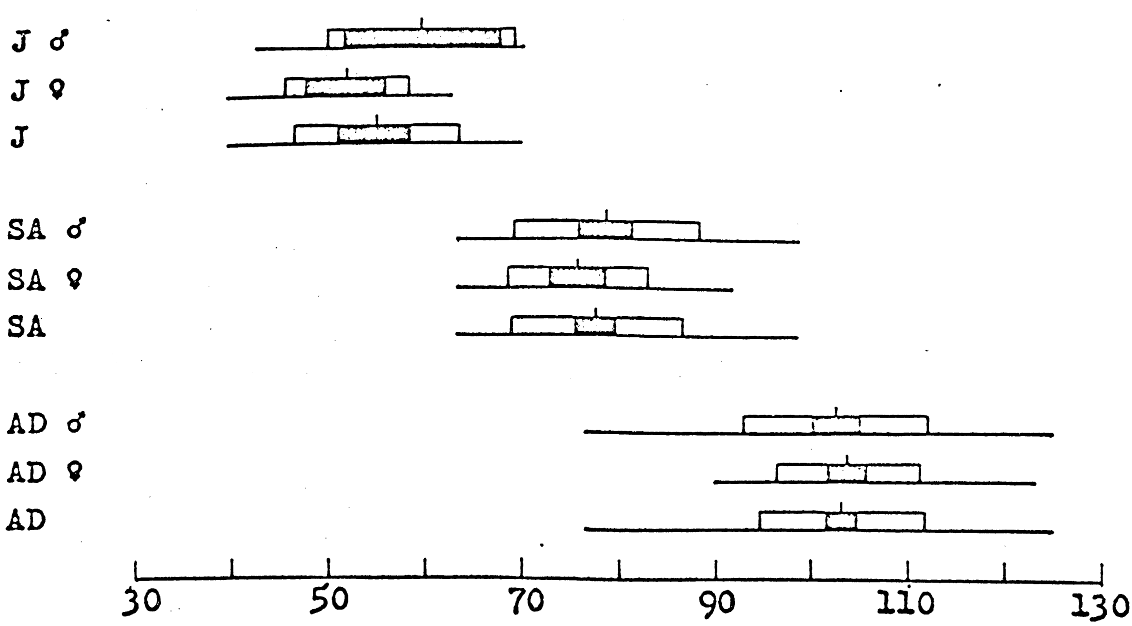

Figure 8. Comparisons of occipitonasal lengths of groups of eastern chipmunks.

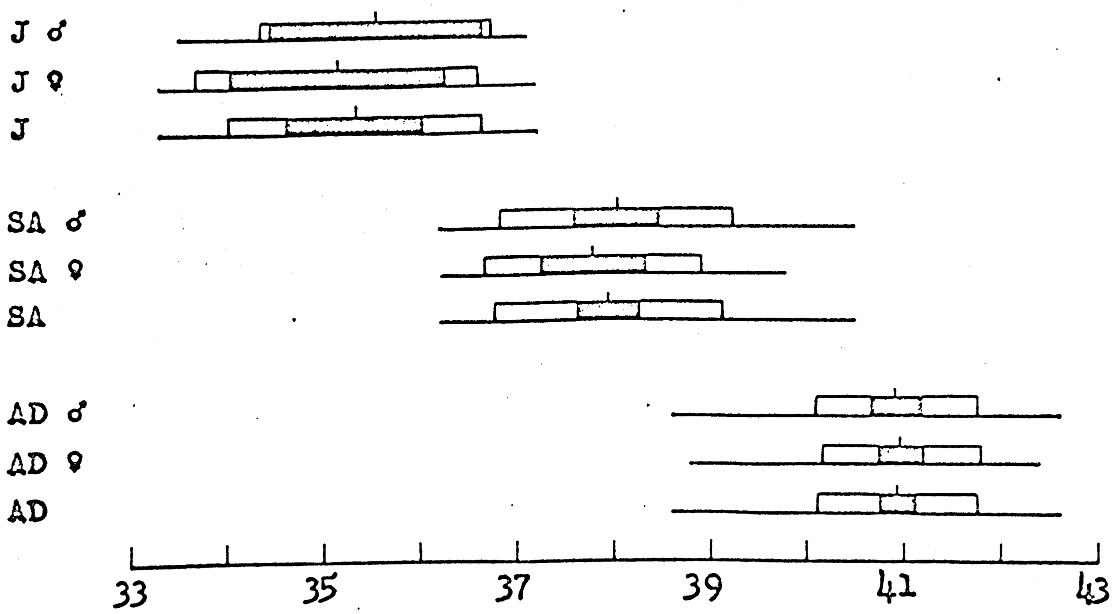

Figure 9. Comparisons of interorbital breadths of groups of eastern chipmunks.

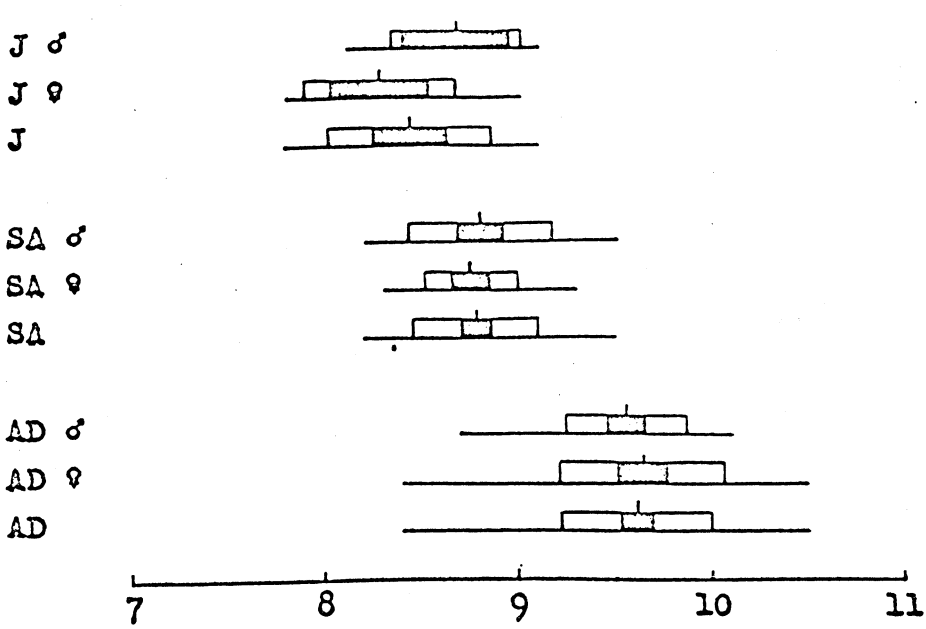

Figure 10. Comparisons of total lengths of groups of least chipmunks.

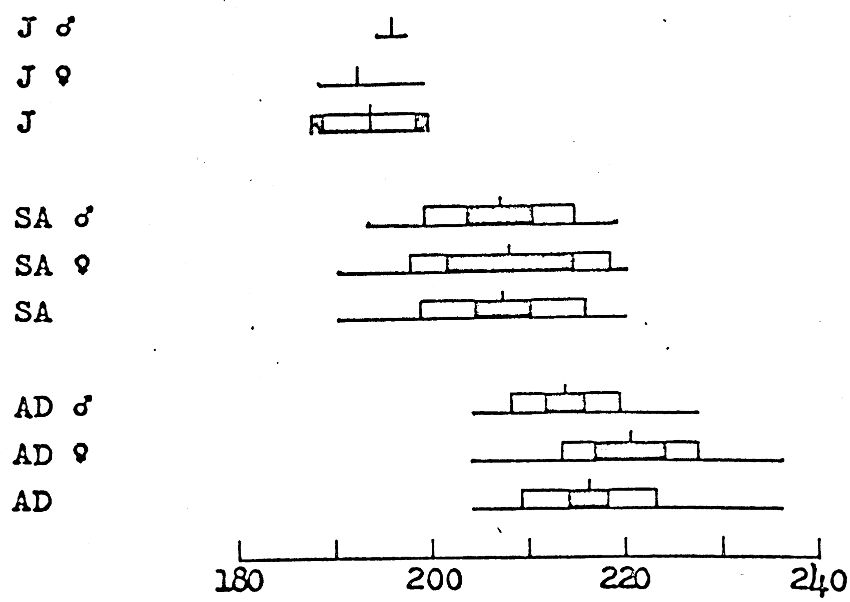

Figure 11. Comparisons of tail lengths of groups of least chipmunks.

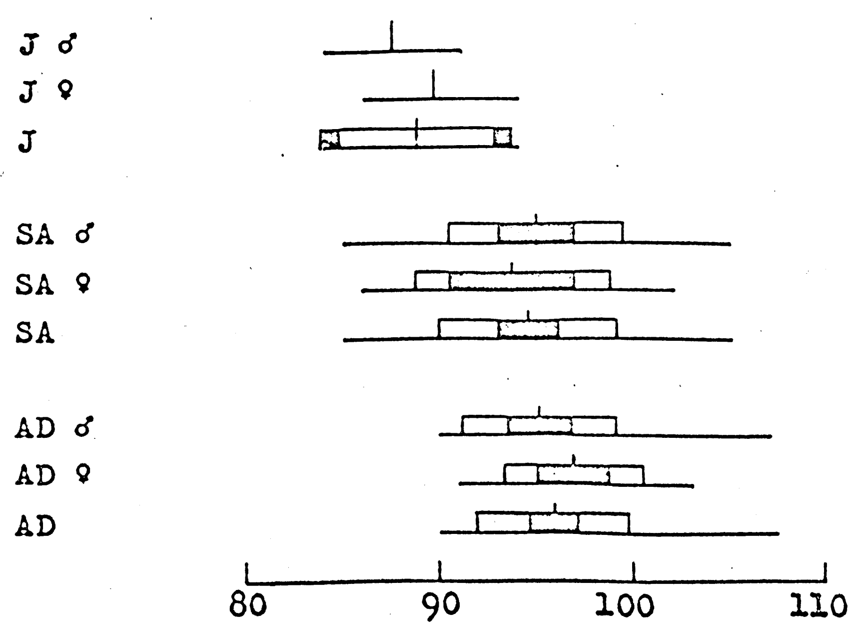

Figure 12. Comparisons of hind foot lengths of groups of least chipmunks.

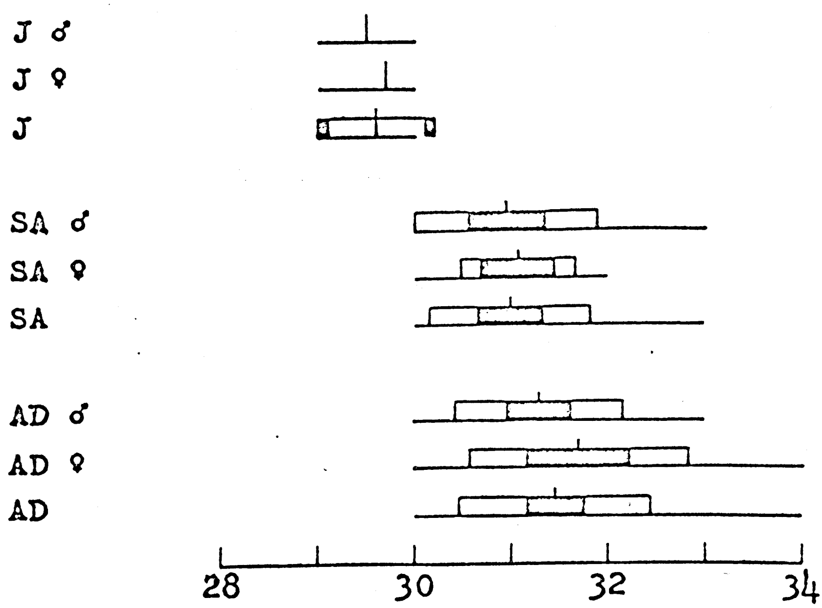

Figure 13. Comparisons of ear lengths of groups of least chipmunks.

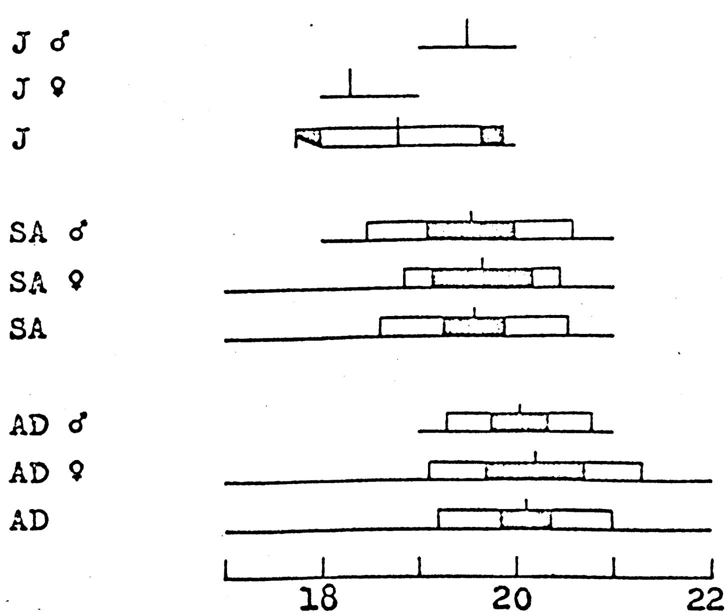

Figure 14. Comparisons of head-and-body lengths of groups of least chipmunks.

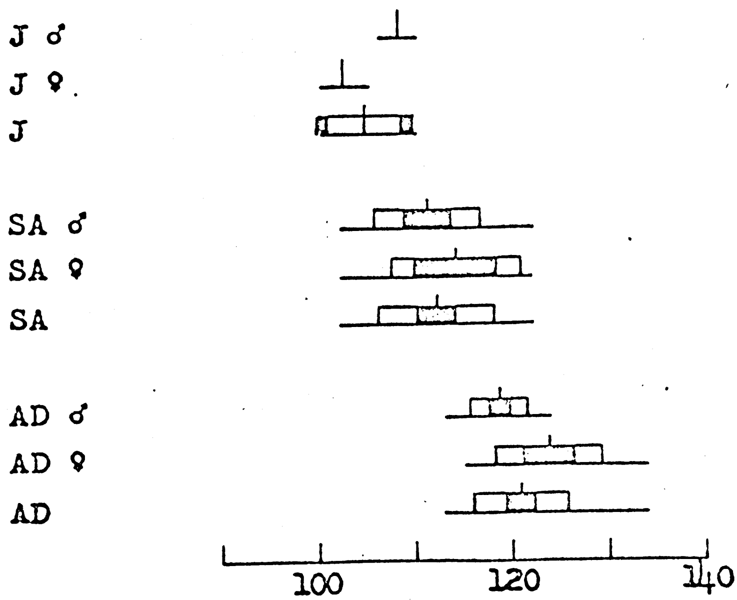

Figure 15. Comparisons of body weights of groups of least chipmunks.

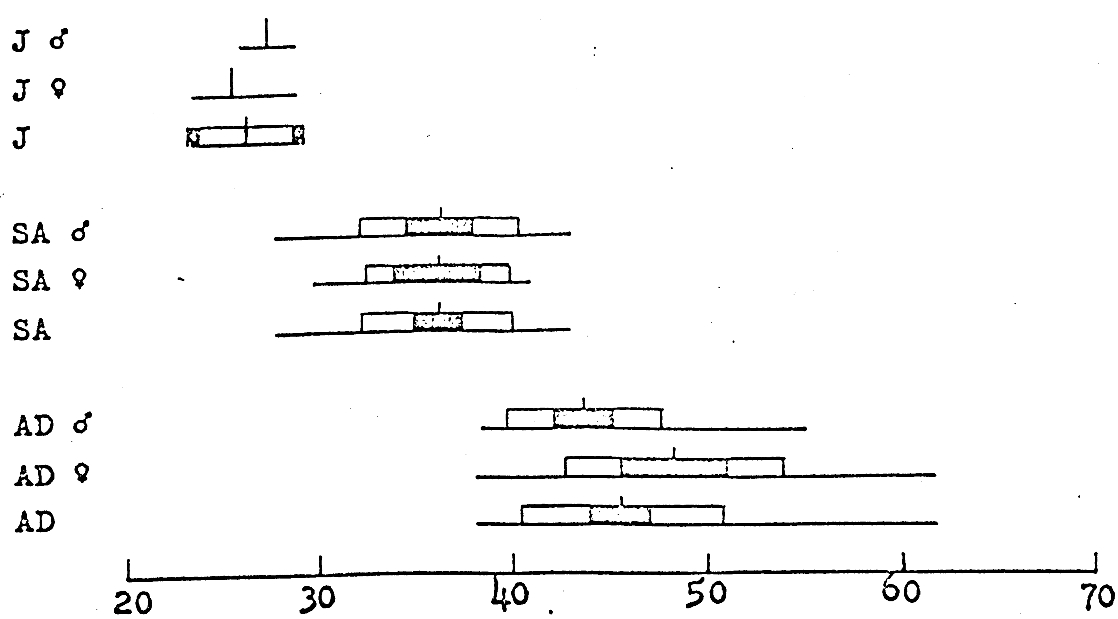

Figure 16. Comparisons of occipitonasal lengths of groups of least chipmunks.

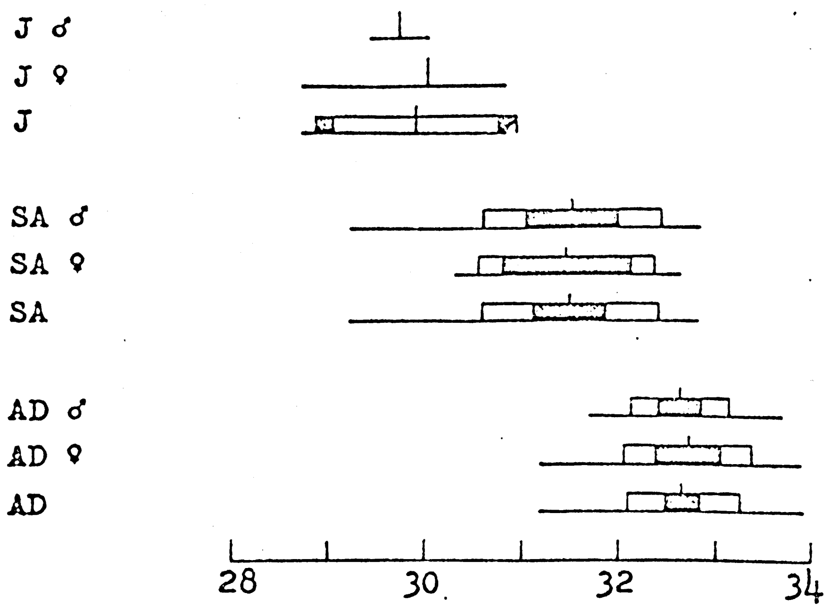

Figure 17. Comparisons of interorbital breadths of groups of least chipmunks.

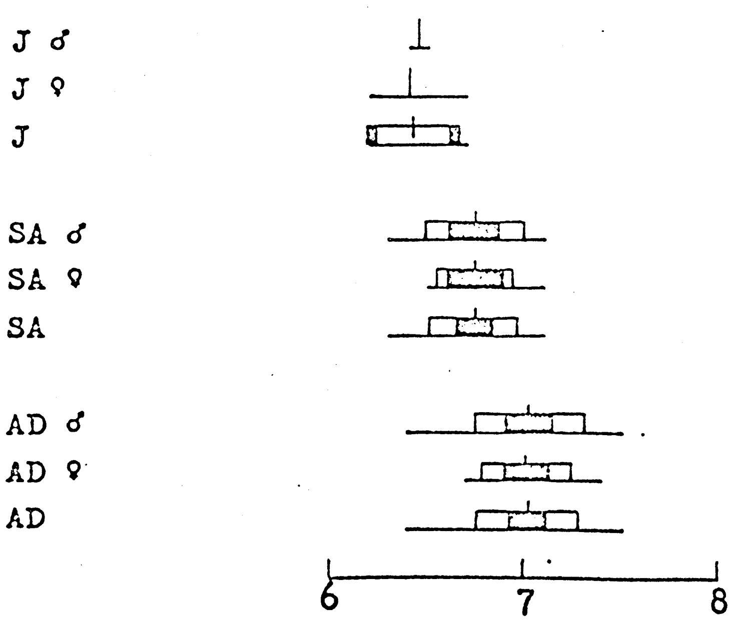

Figure 18. Head-and-body lengths of groups of least chipmunks captured in semimonthly summer periods. Means of adults (dots), subadults (triangles) and juveniles (circles) are shown; horizontal lines enclose the means plus and minus two standard errors of the mean.

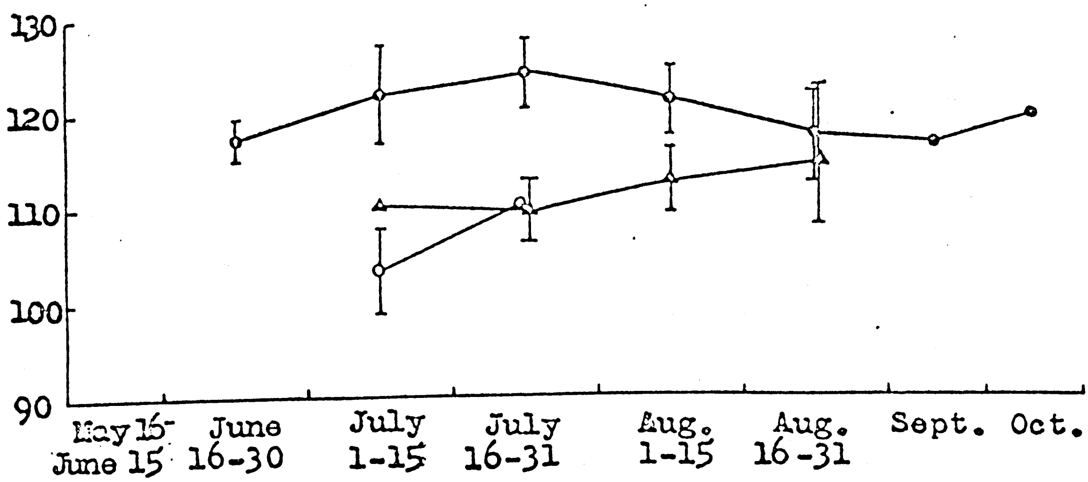

Figure 19. Head-and- body lengths of groups of eastern chipmunks captured in semimonthly summer periods. Symbols as in Figure 18.

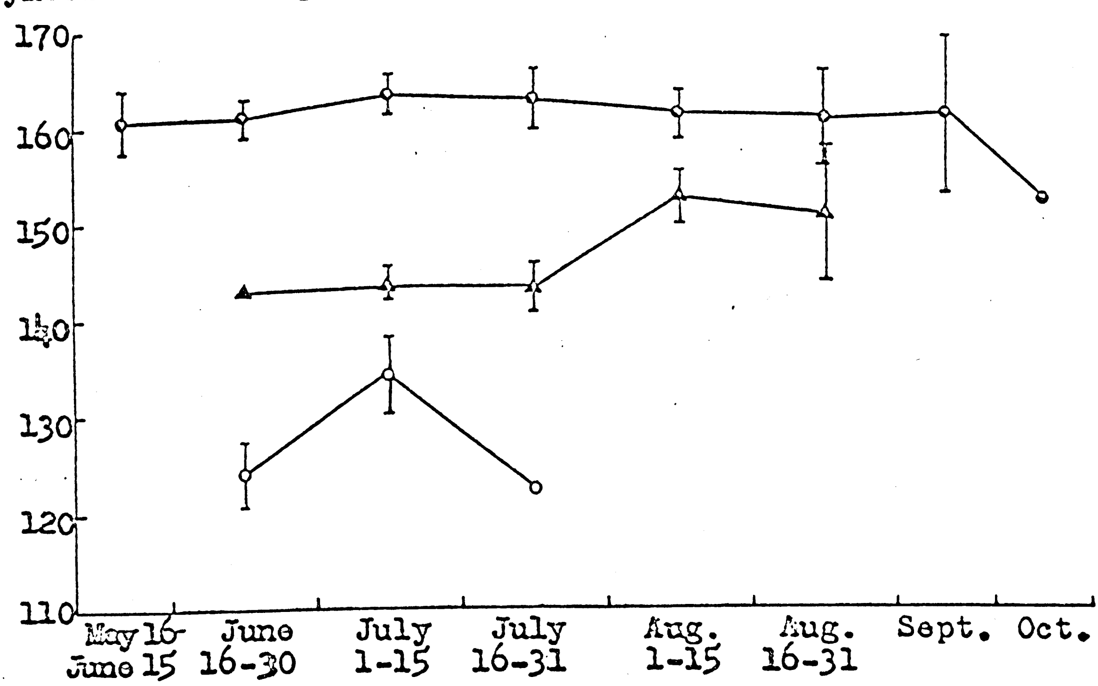

Figure 20. Body weights of groups of least chipmunks captured in semimonthly summer periods. Symbols as in Figure 18.

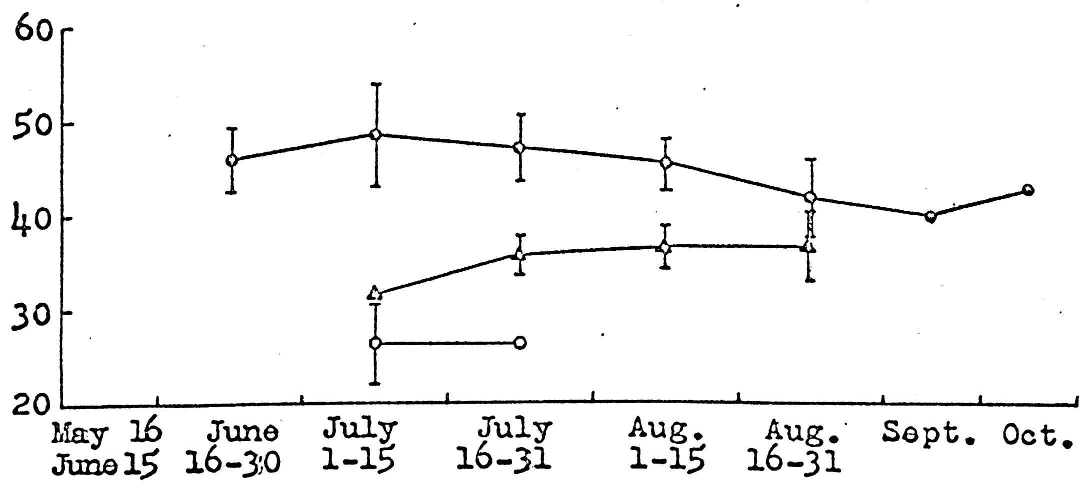

Figure 21. Body weights of groups of eastern chipmunks captured in semimonthly summer periods. Symbols as in Figure 18.

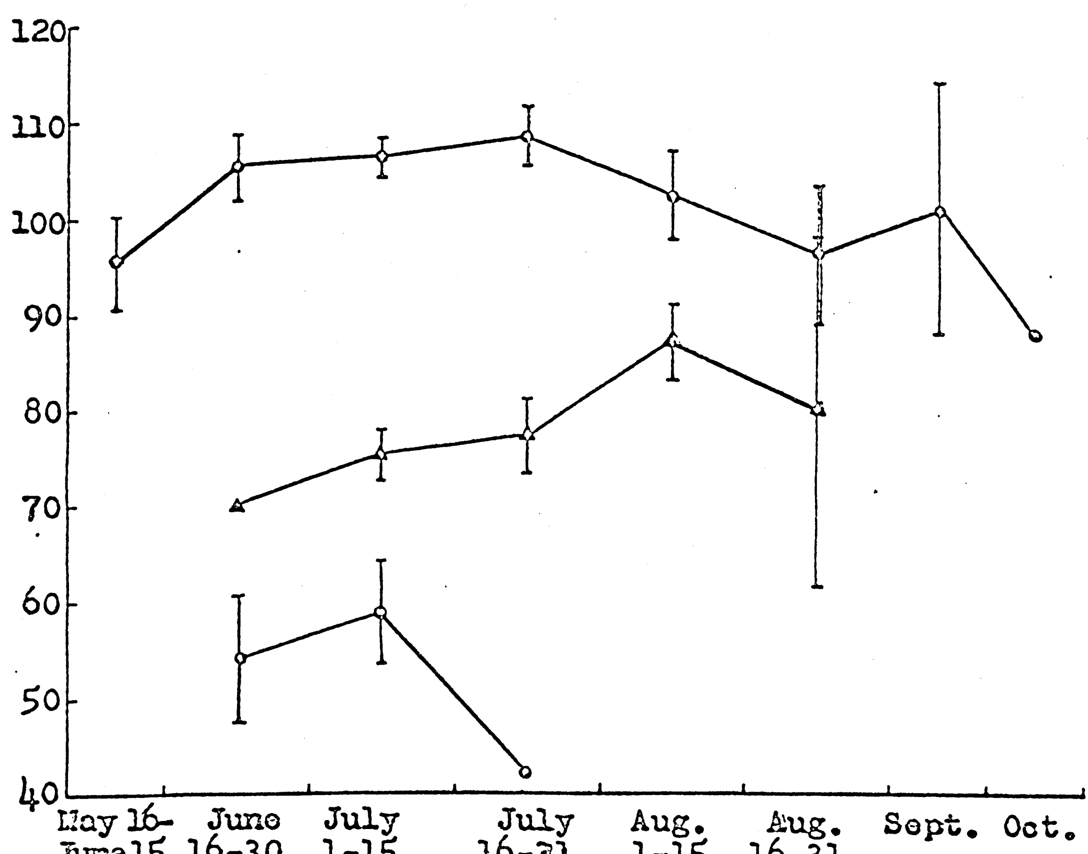

Figure 22. Occipitonasal lengths of groups of least chipmunks captured in semimonthly summer periods. Symbols as in Figure 18.

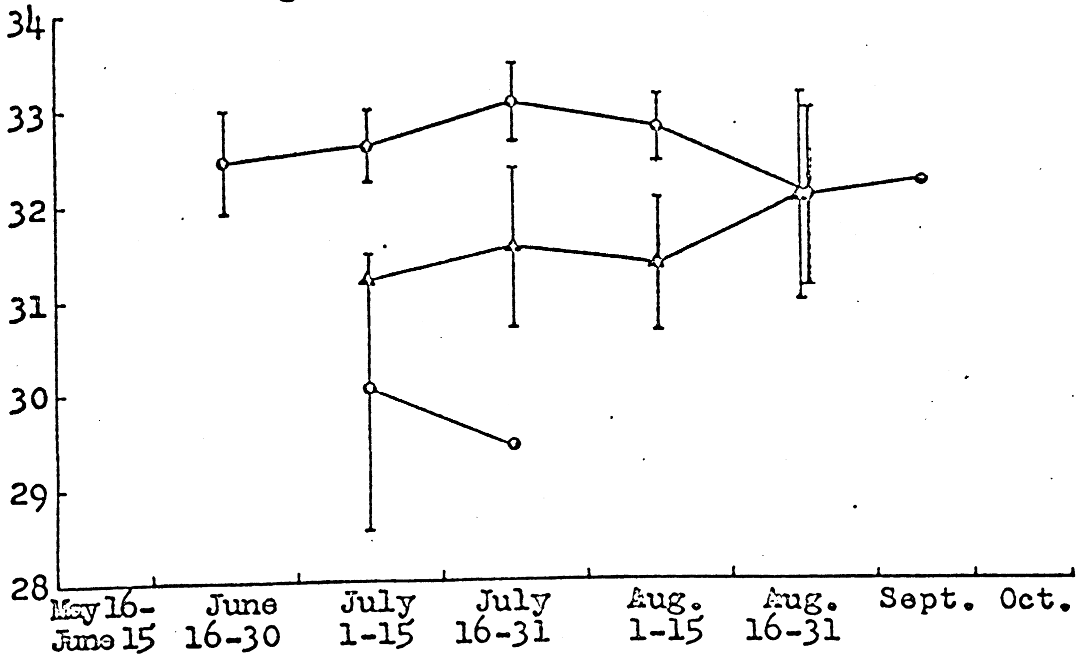

Figure 23. Occipitonasal lengths of groups of eastern chipmunks captured in semimonthly summer periods. Symbols as in Figure 18.

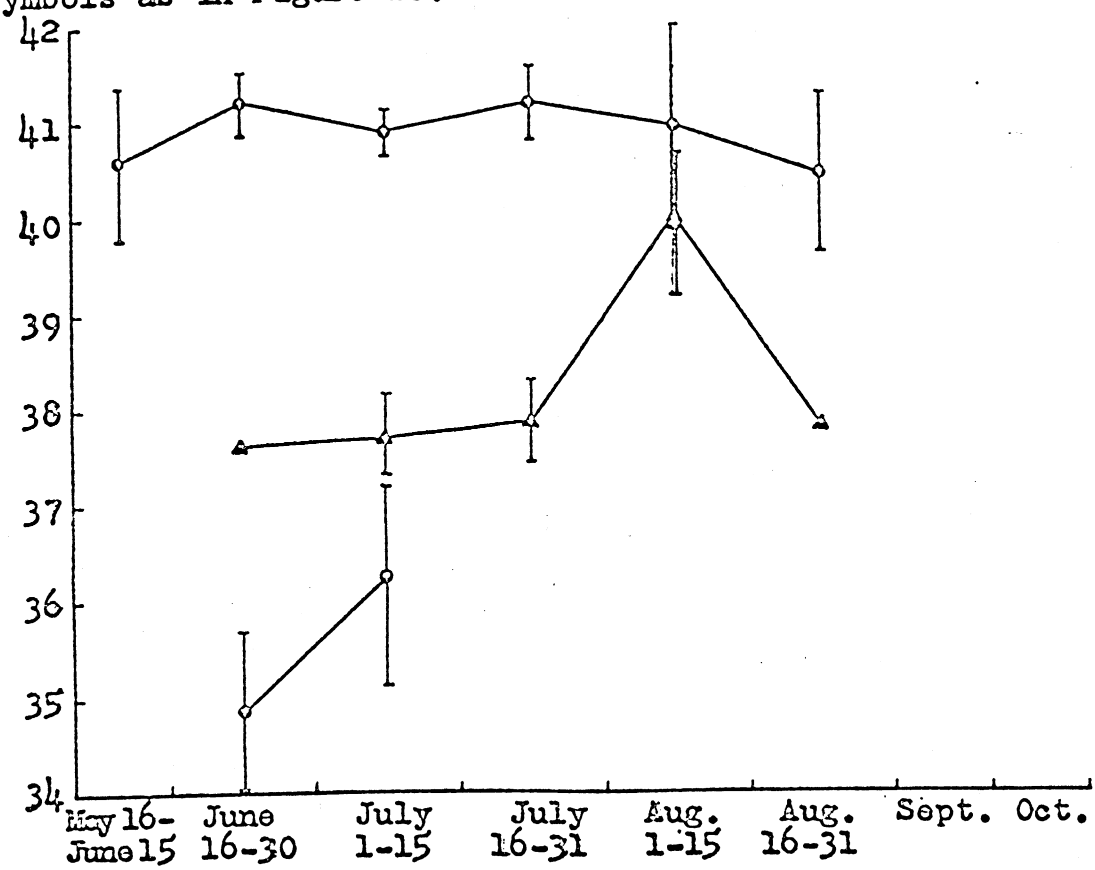

Figure 24. Mean weight changes of chipmunks during dehydration and rehydration.

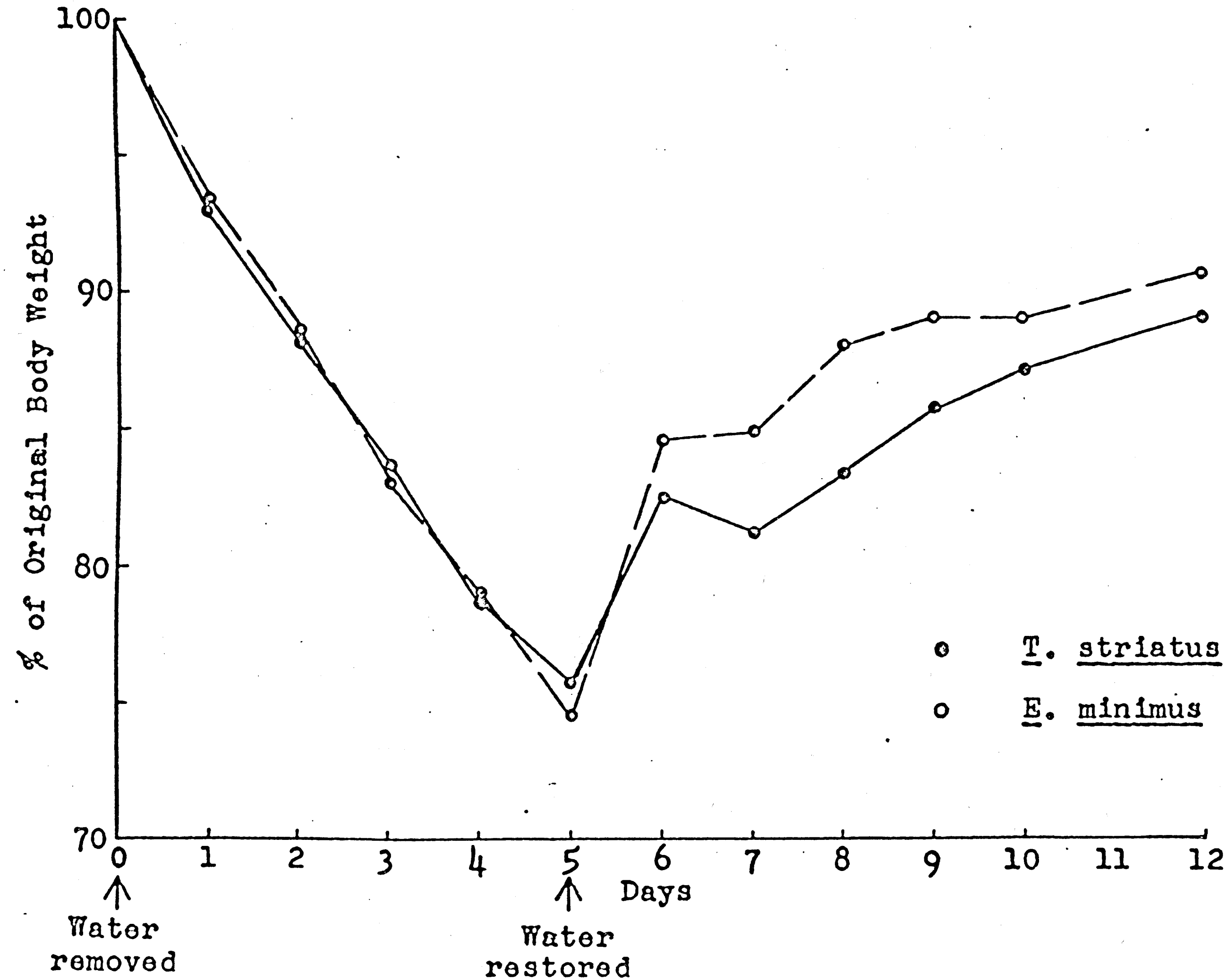

Figure 25. Rectal temperatures of five eastern chipmunks during arousal from torpor. Ambient temperature 15°-20°C.

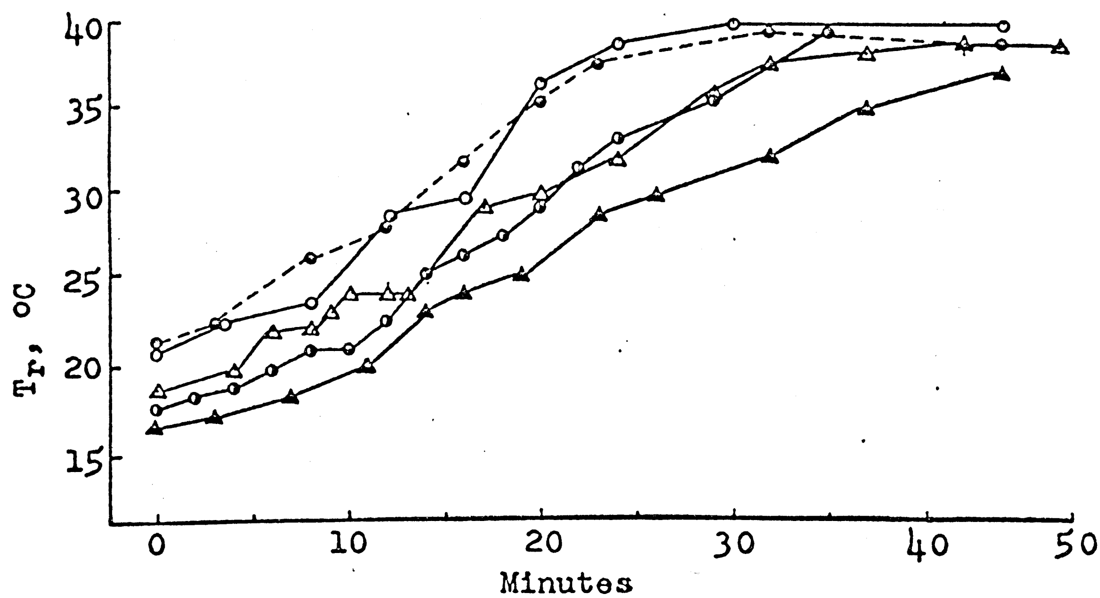

Figure 26. Rectal temperatures of a least chipmunk (△, T_a = 18°C) and an eastern chipmunk (○, removed from T_a = 7°C to T_a = 22°C) during arousal from torpor.

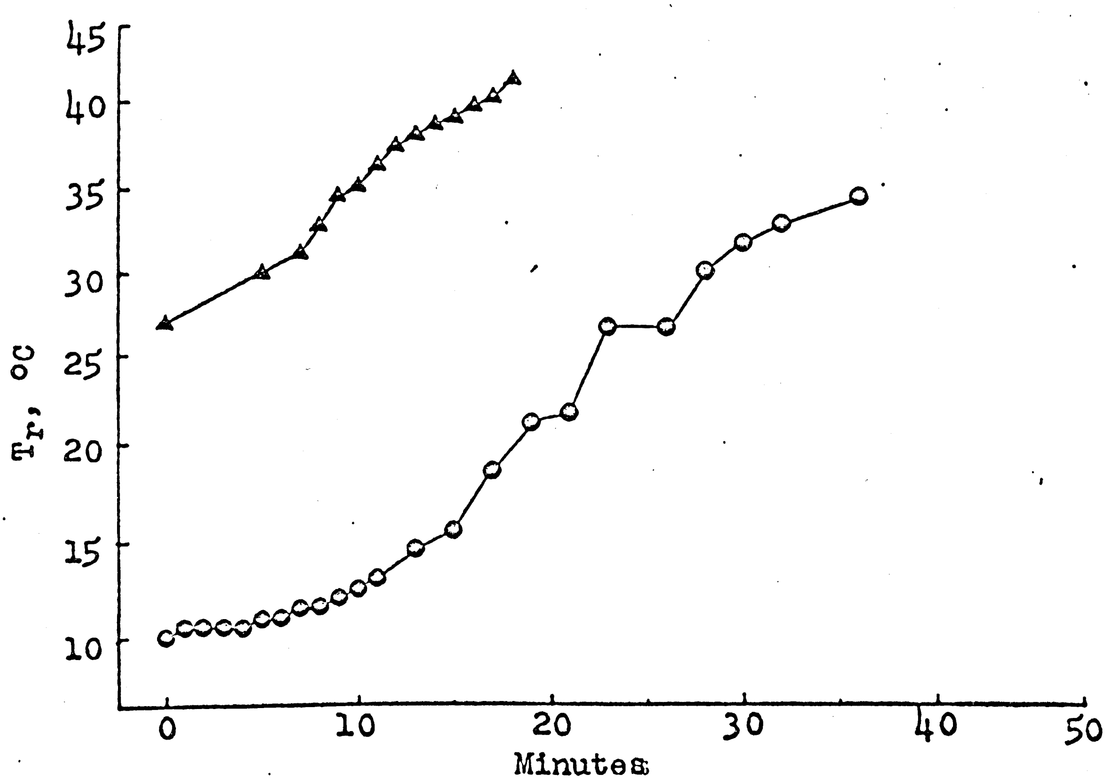

Table 1

Comparisons of Total Lengths of Groups
of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	219.1	4.87	6.3
J	♀	12	217.5	2.95	4.7
J	all	20	218.2	2.56	5.2
SA	♂	43	245.5	1.42	3.8
SA	♀	26	245.4	1.95	4.1
SA	all	69	245.5	1.14	3.9
AD	♂	49	266.9	1.23	3.2
AD	♀	55	269.9	1.04	2.9
AD	all	104	268.5	0.81	3.1

Table 2

Comparisons of Tail Lengths of Groups
of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	89.8	3.43	10.8
J	♀	12	91.1	1.82	6.9
J	all	20	90.6	1.71	8.4
SA	♂	43	100.3	0.78	5.1
SA	♀	26	100.5	1.10	5.6
SA	all	69	100.4	0.63	5.2
AD	♂	49	106.7	0.82	5.4
AD	♀	55	107.4	0.71	4.9
AD	all	104	107.0	0.54	5.1

Table 3

Comparisons of Hind Foot Lengths of Groups

of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	34.4	0.76	6.2
J	♀	12	34.5	0.42	4.2
J	all	20	34.4	0.38	4.9
SA	♂	44	35.9	0.13	2.5
SA	♀	28	36.0	0.14	2.0
SA	all	72	35.9	0.10	2.3
AD	♂	61	36.9	0.12	2.5
AD	♀	60	36.7	0.12	2.6
AD	all	121	36.8	0.09	2.6

Table 4

Comparisons of Ear Lengths of Groups

of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	19.5	0.42	6.1
J	♀	12	19.9	0.19	3.4
J	all	20	19.8	0.21	4.7
SA	♂	44	21.1	0.11	3.6
SA	♀	28	20.9	0.13	3.2
SA	all	72	21.0	0.08	3.4
AD	♂	61	22.0	0.10	3.5
AD	♀	60	22.0	0.13	4.6
AD	all	121	22.0	0.08	4.0

Table 5

Comparisons of Head-and-Body Lengths of Groups of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	129.4	2.45	5.4
J	♀	12	126.4	1.91	5.2
J	all	20	127.6	1.51	5.3
SA	♂	44	145.5	0.91	4.1
SA	♀	28	145.0	1.16	4.3
SA	all	72	145.3	0.71	4.2
AD	♂	61	160.7	0.69	3.3
AD	♀	60	162.7	0.77	3.7
AD	all	121	161.7	0.52	3.6

Table 6

Comparisons of Body Weights of Groups of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	59.42	3.43	16.68
J	♀	12	51.71	1.88	12.61
J	all	20	54.80	1.92	15.72
SA	♂	45	78.73	1.42	12.13
SA	♀	26	75.75	1.41	9.49
SA	all	71	77.64	1.05	11.36
AD	♂	60	102.52	1.24	9.38
AD	♀	60	103.74	0.95	7.12
AD	all	120	103.13	0.78	8.31

Table 7

Comparisons of Occipitonasal Lengths of Groups of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	7	35.54	0.45	3.38
J	♀	9	35.14	0.49	4.14
J	all	16	35.32	0.33	3.74
SA	♂	32	38.04	0.22	3.15
SA	♀	19	37.79	0.26	2.96
SA	all	51	37.95	0.16	3.08
AD	♂	42	40.92	0.13	2.05
AD	♀	46	40.97	0.12	2.00
AD	all	88	40.94	0.09	2.02

Table 8

Comparisons of Interorbital Breadths of Groups of Eastern Chipmunks

Age	Sex	n	Mean	S. E.	V
J	♂	8	8.67	0.12	3.92
J	♀	12	8.28	0.11	4.75
J	all	20	8.44	0.09	4.93
SA	♂	37	8.80	0.06	4.20
SA	♀	24	8.76	0.05	2.74
SA	all	61	8.78	0.04	3.69
AD	♂	42	9.56	0.05	3.22
AD	♀	50	9.64	0.06	4.39
AD	all	92	9.61	0.04	3.91

Table 9

Comparisons of Total Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	193.4	2.16	2.5
SA	♂	23	206.9	1.62	3.8
SA	♀	12	207.8	2.99	5.0
SA	all	35	207.2	1.45	4.2
AD	♂	27	213.7	1.08	2.6
AD	♀	17	220.3	1.70	3.2
AD	all	44	216.2	1.04	3.2

Table 10

Comparisons of Tail Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	88.8	1.78	4.5
SA	♂	23	95.0	0.94	4.8
SA	♀	12	93.8	1.46	5.4
SA	all	35	94.6	0.79	4.9
AD	♂	26	95.2	0.79	4.2
AD	♀	17	96.9	0.88	3.7
AD	all	43	95.9	0.60	4.1

Table 11

Comparisons of Hind Foot Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	29.6	0.22	1.7
SA	♂	24	31.0	0.20	3.1
SA	♀	12	31.1	0.17	1.9
SA	all	36	31.0	0.17	2.7
AD	♂	28	31.3	0.16	2.8
AD	♀	20	31.7	0.26	3.6
AD	all	48	31.5	0.14	3.2

Table 12

Comparisons of Ear Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	18.8	0.34	4.6
SA	♂	24	19.5	0.22	5.4
SA	♀	12	19.7	0.23	4.1
SA	all	36	19.6	0.16	5.0
AD	♂	28	20.0	0.14	3.7
AD	♀	20	20.2	0.25	5.5
AD	all	48	20.1	0.13	4.5

Table 13

Comparisons of Head-and-Body Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	104.6	1.72	3.7
SA	♂	24	111.1	1.14	5.0
SA	♀	12	114.1	1.94	5.9
SA	all	36	112.1	1.01	5.4
AD	♂	27	118.7	0.59	2.6
AD	♀	19	123.7	1.27	4.5
AD	all	46	120.8	0.72	4.1

Table 14

Comparisons of Body Weights of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	26.30	1.10	9.32
SA	♂	24	36.27	0.83	11.22
SA	♀	13	36.18	1.03	10.31
SA	all	37	36.24	0.64	10.76
AD	♂	28	43.70	0.75	9.04
AD	♀	20	48.33	1.29	11.32
AD	all	48	45.63	0.75	11.40

Table 15

Comparisons of Occipitonasal Lengths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	4	29.88	0.38	2.83
SA	♂	16	31.51	0.23	2.95
SA	♀	10	31.45	0.29	2.93
SA	all	26	31.49	0.18	2.08
AD	♂	23	32.63	0.11	1.58
AD	♀	17	32.72	0.16	2.02
AD	all	40	32.67	0.09	1.76

Table 16

Comparisons of Interorbital Breadths of Groups of Least Chipmunks

Age	Sex	n	Mean	S. E.	V
J	all	5	6.42	0.09	3.02
SA	♂	17	6.74	0.06	3.66
SA	♀	11	6.74	0.06	2.95
SA	all	28	6.74	0.04	3.35
AD	♂	22	7.03	0.06	3.98
AD	♀	15	7.01	0.06	3.21
AD	all	37	7.02	0.04	3.65

Table 17

Comparisons of Size Measurements of Groups of Eastern Chipmunks

Explanation: X = significant difference ($p \leq 0.05$), 0 = no significant difference, HBL = head-and-body length, ONL = occipitonasal length, and IOB = interorbital breadth.

Groups	Total Length	Tail Length	H. Foot Length	Ear Length	HBL	Body Weight	ONL	IOB
J-SA	X	X	X	X	X	X	X	X
J-AD	X	X	X	X	X	X	X	X
SA-AD	X	X	X	X	X	X	X	X
J♂-J♀	0	0	0	0	0	0	0	0
J♂-SA♂	X	X	0	X	X	X	X	0
J♂-SA♀	X	X	0	X	X	X	X	0
J♀-SA♂	X	X	X	X	X	X	X	X
J♀-SA♀	X	X	X	X	X	X	X	X
SA♂-SA♀	0	0	0	0	0	0	0	0
SA♂-AD♂	X	X	X	X	X	X	X	X
SA♂-AD♀	X	X	X	X	X	X	X	X
SA♀-AD♂	X	X	X	X	X	X	X	X
SA♀-AD♀	X	X	X	X	X	X	X	X
AD♂-AD♀	0	0	0	0	0	0	0	0

Table 18

Comparisons of Size Measurements of Groups of Least Chipmunks

Explanation as in Figure 17.

Groups	Total Length	Tail Length	H. Foot Length	Ear Length	HBL	Body Weight	ONL	IOB
J-SA	X	0	X	0	X	X	X	X
J-AD	X	X	X	0	X	X	X	X
SA-AD	X	0	0	0	X	X	X	X
SA♂-SA♀	0	0	0	0	0	0	0	0
SA♂-AD♂	X	0	0	0	X	X	X	X
SA♂-AD♀	X	0	0	0	X	X	X	X
SA♀-AD♂	0	0	0	0	0	X	X	X
SA♀-AD♀	X	0	0	0	X	X	X	X
AD♂-AD♀	X	0	0	0	X	X	0	0

Table 19

Numbers, Ages, and Reproductive Condition of Eastern Chipmunks Captured in Semimonthly Summer Periods During 1962 and 1963

	Males				Females				
	Age class				Age class				
Period	J	SA	AD	Pendulous Testes (AD)	J	SA	AD	Preg. (AD)	Lact. (AD)
Late May	0	0	4	4	0	0	3	0	0
Early June	0	0	7	7	0	0	2	0	1
Late June	4	1	16	5	7	1	13	1	1
Early July	3	21	14	0	6	11	19	0	1
Late July	1	14	6	0	0	8	15	0	0
Early Aug.	0	7	7	0	0	5	3	0	0
Late Aug.	0	2	4	0	0	2	4	0	0
Early Sept.	0	0	2	0	0	0	2	0	0
Early Oct.	0	0	1	0	0	0	0	0	0

Table 20

Numbers, Ages, and Reproductive Condition of Least Chipmunks Captured in Semimonthly Summer Periods During 1962 and 1963

	Males				Females				
	Age class				Age class				
Period	J	SA	AD	Pendulous Testes (AD)	J	SA	AD	Preg. (AD)	Lact. (AD)
Late June	0	0	7	1	0	0	3	0	2
Early July	1	0	2	0	3	1	7	0	4
Late July	1	8	8	0	0	3	3	0	0
Early Aug.	0	12	7	0	0	5	3	0	0
Late Aug.	0	3	2	0	0	3	4	0	0
Late Sept.	0	0	2	0	0	0	1	0	0
Early Oct.	0	0	1	0	0	0	1	0	0

Table 21

Pouch Contents of Eastern and Least Chipmunks

The number of animals whose pouches contained the seeds of a given species of plant is shown. Information on plant habitats is summarized from Fernald (1950) and Gleason and Cronquist (1963).

Plant Species	Habitat of Plant Species	Tamias striatus	Eutamias minimus
Prunus sp.	Thickets, shores, wood borders	11	0
Amelanchier sp.	Dry or moist woods	4	0
Oryzopsis asperifolia	Upland woods, thickets, peaty openings	4	0
Corylus sp.	Thickets, open woods	3	0
Fagopyrum esculentum	Old fields; escaped from cultivation	3	0
Lathyrus ochroleucus	Dry or moist woods and thickets	2	0
Quercus macrocarpa	Dry uplands	2	0
Acer rubrum	Swamps, moist uplands	1	0
Cenchurus sp.	Dry sands	1	0
Echinocystis lobata	Rich moist soil near streams and in thickets.	1	0
Gramineae, unid. sp.	---	1	0
Polygonum convolvulus	Waste ground	1	0
Rhus radicans	Woods and various other places	1	0
Smilacina	Woods, clearings, bogs	1	0
Fragaria virginiana	Borders of woods	1	1

Table 21, cont'd.

Plant Species	Habitat of Plant Species	*Tamias striatus*	*Eutamias minimus*
Hepatica americana	Dry woods, acid soils	1	1
Carex sp.	Variable, diverse	0	1
Cirsium arvense	Cultivated and waste ground	0	1
Panicum xanthophysum	Dry, rocky or sandy open soil, or thin woods	0	1
Potentilla palustris	Bogs, wet meadows, stream banks	0	1
Setaria lutescens	Cultivated and waste ground	0	1
Thalictrum dioicum	Rich, moist, rocky woods	0	1
Schizachne purpurascens	Thickets, dry rocky and sandy woods	0	2
Rubus minnesotanus	Dry clearings	0	5
Avena sativa	Cultivated	2	3
Triticum aestivum	Cultivated	3	2
Zea mays	Cultivated	2	0
Miscellaneous vegetation	---	6	0
Insect material	---	2	1

Table 22

Numbers of Eastern Chipmunk Stomachs Containing Animal Matter

Yes

129

(73 ♂♂, 56 ♀♀)

J	SA	AD
18	48	63
(8 ♂♂, 10 ♀♀)	(33 ♂♂, 15 ♀♀)	(32 ♂♂, 31 ♀♀)
14% of 129	37% of 129	49% of 129
86% of J's	83% of SA's	69% of AD's

No

41

(16 ♂♂, 25 ♀♀)

J	SA	AD
3	10	28
(0 ♂♂, 3 ♀♀)	(6 ♂♂, 4 ♀♀)	(10 ♂♂, 18 ♀♀)
7% of 41	25% of 41	68% of 41
14% of J's	17% of SA's	31% of AD's

Table 23

Numbers of Least Chipmunk Stomachs Containing Animal Matter

Yes

27

(19 ♂♂, 8 ♀♀)

J	SA	AD
1	9	17
(1 ♂, 0 ♀♀)	(7 ♂♂, 2 ♀♀)	(11 ♂♂, 6 ♀♀)
4% of 27	33% of 27	63% of 27
25% of J's	41% of SA's	44% of AD's

No

38

(20 ♂♂, 18 ♀♀)

J	SA	AD
3	13	22
(1 ♂, 2 ♀♀)	(7 ♂♂, 6 ♀♀)	(12 ♂♂, 10 ♀♀)
8% of 38	34% of 38	58% of 38
75% of J's	59% of SA's	56% of AD's

Table 24

Results of Contingency Table Tests for Significance of Difference in Animal Matter Consumption by Groups of Chipmunks

Explanation: Jl = juvenile least chipmunks, Je = juvenile easterns, SAl = subadult leasts, SAe = subadult easterns, ADl = adult leasts, and ADe = adult easterns. P is the probability that, in a given comparison, the proportion of stomachs from each group that have and that lack animal matter differ from each other to the observed extent due to chance alone. X^2= Chi-square; X_c^2 = Chi-square adjusted with Yates' correction for continuity.

Comparison	X^2	X_c^2	P
Je:SAe	0.10	0.001	.75-.98
Je:ADe	2.31	1.56	.10-.25
SAe:ADe	3.3	--	.05-.10
Jl:SAl	0.36	0.002	.50-.95
Jl:ADl	0.51	0.034	.25-.75
SAl:ADl	0.04	0.004	.90-.95
Jl:Je	4.07	3.89	.025-.05
SAl:SAe	13.7	11.7	less than .005
ADl:ADe	7.5	--	.005-.01

Table 25

Water Consumption by Confined Eastern Chipmunks During 18 Days in Late Summer

	Animal No.								
	E1	E2	E3	E4	E5	E6	E7	E8	E9
Mean Wt. of Animal--g	117.6	102.8	120.5	117.6	125.0	106.4	106.3	106.1	132.8
Total H_2O Consumed--ml	369	208	274	258	256	257	258	314	471
Mean H_2O Cons./day--ml	20.5	11.6	15.2	14.3	14.2	14.3	14.3	17.4	26.2
H_2O Cons./g--ml	3.1	2.0	2.3	2.2	2.1	2.4	2.4	3.0	3.5
Mean H_2O Cons./g/day--ml	0.17	0.11	0.13	0.12	0.11	0.13	0.14	0.16	0.20

Table 26

Water Consumption by Confined Least Chipmunks During 18 Days in Late Summer

Animal No.

	L1	L2	L3	L4	L5	L6	L7	L8	L9
Mean Wt. of Animal--g	49.4	46.2	44.4	44.4	46.4	47.7	50.2	42.0	45.0
Total H_2O Consumed--ml	80	76	112	89	81	150	94	101	97
Mean H_2O Cons./day--ml	4.4	4.2	6.2	4.9	4.5	8.3	5.2	5.6	5.4
H_2O Cons./g--ml	1.6	1.6	2.5	2.0	1.7	3.1	1.9	2.4	2.1
Mean H_2O Cons./g/day--ml	0.09	0.09	0.14	0.11	0.10	0.18	0.10	0.13	0.12

Table 27

Means and Standard Errors of Water Consumption of Confined Eastern Chipmunks

Value	Mean	S. E.	V
Total H_2O Consumed--ml	296.1	26.5	26.8
Mean H_2O Cons./day--ml	16.4	1.5	26.8
H_2O Cons./g--ml	2.6	0.18	20.8
Mean H_2O Cons./g/day	0.14	0.01	20.8

Table 28

Means and Standard Errors of Water Consumption of Confined Least Chipmunks

Value	Mean	S. E.	V
Total H_2O Consumed--ml	97.8	7.6	23.2
Mean H_2O Cons./day--ml	5.4	0.4	23.2
H_2O Cons./g--ml	2.1	0.17	23.5
Mean H_2O Cons./g/day	0.12	0.01	23.6

Table 29

Weight Changes (%) of Eastern Chipmunks During Dehydration and Rehydration

Animal No.

Day No.	E1	E2	E3	E4	E5	E6	E7	E8	E9	$\bar{X}$
Animal's wt. (g) when H_2O removed:	126.2	102.7		125.6	136.8	103.1		108.2	149.9	
0	100.0	100.0		100.0	100.0	100.0		100.0	100.0	100.0
1	93.7	89.9		92.0	92.9	95.5		92.6	94.3	93.0
2	87.6	85.5		87.7	88.6	91.6		85.9	90.5	88.2
3	82.2	80.0	Control	84.1	85.2	86.7	Control	81.0	86.1	83.6
4	77.8	75.7		80.7	74.6	83.0		76.1	82.5	78.6
5	72.8	71.4		78.0	78.8	79.3		70.4	79.4	75.7
H_2O restored:										
6	83.8	76.6		85.4	83.7	82.7		81.0	84.0	82.5
7	83.2	67.8		82.6	84.4	Dead		83.2	85.5	81.1
8	83.4	63.6		92.8	86.9			86.6	86.6	83.3
9	85.7	62.8		94.3	90.0			92.6	88.8	85.7
10	88.2	59.4		97.4	94.4			94.7	88.2	87.0
12	88.5	57.9		100	99.7			100	88.5	89.1

Table 30

Weight Changes (%) of Least Chipmunks During Dehydration and Rehydration

Day No.	L1	L2	L3	L4	L5	L6	L7	L8	L9	$\bar{X}$
Animal's wt. (g) when H_2O removed:	50.2	49.0	42.3	45.3	46.8	48.5	51.9			
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0			100.0
1	93.6	93.9	94.1	93.6	94.0	89.5	95.4			93.4
2	89.2	88.8	87.7	91.6	87.8	85.6	89.6			88.6
3	83.5	84.6	84.6	85.2	81.2	79.2	82.3			82.9
4	78.1	80.6	80.6	83.7	75.9	74.8	78.0	Control	Control	78.8
5	74.7	78.2	77.8	79.2	69.4	71.5	73.2			74.9
H_2O restored:										
6	80.9	84.3	92.0	89.2	80.8	85.2	80.7			84.7
7	77.3	84.5	95.0	91.6	82.3	83.1	80.7			84.9
8	79.1	86.3	96.5	93.6	88.5	Dead	84.4			88.1
9	80.7	86.3	100	92.7	91.5		83.6			89.1
10	79.9	88.6		92.9	89.7		83.2			89.1
12	82.7	88.1		92.5	93.2		87.1			90.6

Table 31

Rectal Temperatures of Sleeping and Active Chipmunks

Species	n	Activity State	Mean	S. E.	t	V
T. striatus	21	Sleeping (December, T_a=15-20°C)	32.6	1.3	1.74	18.2
E. minimus	16	"	35.4	0.6		7.2
T. striatus	65	Active (May, T_a=23-25°C	40.1	0.8	1.69	2.0
E. minimus	65	"	40.4	0.6		1.5

Table 32

Percentages of Fat and Water in

Eastern Chipmunks Between June and October, 1963

June:

Age	% fat	% H_2O
AD	1.9	70.0
AD	3.8	72.0
AD	2.6	72.7
AD	2.8	71.9
AD	3.6	71.6
AD	3.8	71.7
SA	2.8	75.4

July:

Age	% fat	% H_2O
AD	5.5	70.9
AD	3.4	71.1
AD	2.1	71.9
AD	1.8	71.6
AD	3.9	71.8
AD	3.8	70.4
SA	1.7	74.3

Aug.:

Age	% fat	% H_2O
AD	3.5	71.5
AD	4.4	72.5
AD	2.3	72.9
AD	2.9	71.7
AD	3.2	70.0
AD	2.8	71.9
AD	1.8	71.6
SA	2.4	72.7
SA	2.8	72.0
SA	2.2	73.2
SA	8.3	68.8

Sept.:

Age	% fat	% H_2O
AD	1.0	72.0
AD	2.0	71.5
AD	2.6	71.9
AD	6.2	69.8

Oct.:

Age	% fat	% H_2O
AD	1.9	73.4

Table 33

Percentages of Fat and Water in

Least Chipmunks Between July and October, 1963

July: Age	% fat	% H_2O
AD	4.5	71.7
AD	4.8	72.0
AD	3.1	73.3
AD	5.3	68.9
SA	4.3	71.8
SA	1.6	74.1
SA	3.3	73.0

Aug.: Age	% fat	% H_2O
AD	3.1	74.4
SA	3.0	72.7
SA	2.7	73.0
SA	3.5	73.0
SA	3.0	74.2

Oct.: Age	% fat	% H_2O
AD	5.0	69.7
AD	7.4	67.6

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